SYSTEMS SIMULATION IN REGIONAL PLANNING
A CASE STUDY IN CENTRAL-WEST BRAZIL

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I declare that this thesis
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ABSTRACT

The purpose of this thesis is to provide a procedural framework for regional planning that reconciles the work of planners with the requirements of the decision-making process. It is intended to achieve this by means of a flexible arrangement of normal planning activities according to a cybernetic approach reinforced by the use of computer simulation.

The work was carried out in two parts, which comprise nine chapters and three appendices.

Part One contains a critical analysis of current regional planning practice in Latin America and proposes a procedural framework to overcome some of the deficiencies identified.

After reviewing planning procedures and the main theories of regional development, Chapter One concludes that the weaknesses of existing theories limit the knowledge of regional planners about the systems with which they deal, while deficiencies in planning procedures are responsible for introducing unexpected distortions into such systems through the instruments used for modifying their structure and behaviour.

Chapter Two concentrates on the procedural deficiencies of regional planning and proposes a flexible approach (the "strategy-projects approach") based on cybernetics and systems theory, aiming at a major integration of planning with the decision-making process. This approach relies heavily on computer simulation for assessing the probable effects of alternative courses of action.

Part Two is devoted to the application of the proposed methodology to the Upper Paraguay River Basin in Central-West Brazil.

Chapter Three summarizes the main features of the simulation model and contains a brief characterization of the region, while Chapters Four to Seven are devoted to a detailed description of the model and the econometric work carried out for its calibration.

In Chapter Eight a strategy for regional development is proposed and its expected effects on the regional system are evaluated through simulations of the model.

Chapter Nine presents an appraisal of the advantages and weaknesses of the strategy-projects approach. It also includes an evaluation of the model's performance and a brief discussion about the way it could be improved.

Finally, three appendices containing a more detailed presentation of some of the basic aspects considered in the thesis are presented as a complement to the main text.

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PREFACE

There is a growing concern among Latin American experts and public authorities about the poor results exhibited by planning activities.

As De Mattos (DE MATTOS, 1978) points out planning, ever since its origins, has been linked to highly ambitious objectives and viewed in a relatively optimistic perspective, which is why it has generated very high and certainly unrealistic expectations in relation to what the reigning conditions in each country made it possible to expect. In contrast to this, in the time that has elapsed since then the mechanisms of planning have not operated in the way that was predicted and the results obtained have fallen short of the objectives that had been established from the outset. All this has generated a situation of generalized frustration and growing scepticism in relation to planning, a situation which has been characterized as "the planning crisis".

These comments are also valid for regional planning. In fact, a large proportion of regional development plans have never reached the stage of implementation and those already implemented have not produced particularly impressive results. This lack of efficiency of regional planning should be regarded as the consequence of the use of excessively rigid planning procedures together with limited theories of regional development.

The weaknesses of regional development theories lead to an imperfect knowledge of the structure and behaviour of regional systems, which in turn introduces a good deal of uncertainty into planning proposals.

Deficiencies in planning procedures, for their part, are responsible for the low level of integration of planning with the decision-making process and also for the wide-spread tendency to produce excessively rigid and too detailed plans that frequently prove inadequate as a guide to suitable action.

In general terms it can be said that the proper outcome of regional planning should consist of a set of decisions regarding the way in which available policy instruments will be managed, together with a set of projects involving direct action on the part of the regional administration.

Obviously this is not a simple task and, to a great extent, its complexity derives from the dynamism of regional systems, the limitations of the planner's ability to control such systems and also from the fact that planning proposals have to be translated into feasible projects before implementation. Let us briefly examine these aspects.

The dynamic character of regional systems is the consequence of their "openness", complexity and adaptive behaviour. Because of this, the state of such systems is liable to change in response to a wide range of stimuli, the implementation of planning proposals being only a small part of the wider set of possible stimuli. Therefore, in guiding the regional system towards a desired future state authorities and planners can handle only a few instruments with limited effects. The recognition of this situation is very important, since the existence of uncontrollable disturbances and processes clearly reduces the degree of command of the system on the part of planners. From this it follows that effective planning must maximize the use of the system's capacity for self-regulation.

The second aspect to be considered deals with the limitation of the planner's ability to control regional systems, which can be viewed as basically determined by the type of policy instruments available for intervening in such systems.

The concept of policy instruments comprises all laws, norms and regulations that the regional government is able to use for guiding the behaviour of the elements of the regional system, as well as all actions it can undertake directly.The practical scope of each policy instrument at the regional scale is not fixed and depends to a large extent on the ability of the region to bargain with the central government.

Regional authorities and planners, therefore, not only have to define to what extent and how each policy instrument is to be managed, but must also negotiate with the central government in order to obtain a major control over such instruments, as well as a wider range of action. This is perhaps one of the most important results to be expected from regional planning, since these negotiations define the parametric framework for regional development.

Finally, regional planners have to bear in mind that their proposals have to be expressed in the form of feasible interventions in the system before decisions and orders for their implementation may be made. In fact, induced changes in the system's structure and behaviour are to be seen as the outcome of specific actions (investments, administrative measures, special activities, etc.) undertaken either by the public administration or by private agents. Therefore, to the extent that proper action constitutes the real stimuli to which the regional system reacts, its identification and study (formulation projects) is one of the central aspects of effective planning.

Thus, planners trying to rationalize and dynamize the process of regional development have to be careful to harmonize direct public action with induced private action, and also to ensure that specific actions and projects are compatible with the general policy framework.

The consideration of these characteristics of regional planning leads us to conclude that effective planning at the regional scale has to be organized on the basis of a flexible arrangement of activities for allowing negotiation with private and external agents, must be strongly connected with the decision-making process in order to obtain a high speed of response and, above all, requires a set of tools that provide it with the requisite variety for matching the complexity of the regional system.

Naturally, such requirements entail a greater theoretical development of both the substantive and procedural frameworks of regional planning.

This thesis concentrates on the procedural deficiencies in regional planning and proposes a flexible approach based on cybernetics and systems theory that aims at a major integration of planning with the decision-making process. Such an integration is expected to contribute to the increased efficacy of planning by simplifying its operational procedures and by increasing its flexibility through a greater approximation of planners and authorities in charge of policy formulation and direct action.

The work was organized in two parts, comprising nine chapters. They are complemented by three appendices which contain a more detailed presentation of certain basic aspects.

Part One is devoted to a theoretical analysis of the main features of current theories of regional development and of the procedural context of Latin American regional planning practice. It also proposes a methodological approach to the organization of planning activities that is expected to help to solve some of the procedural deficiencies identified.

Part Two contains the results of the application of the proposed methodology to the study carried out for the Upper Paraguay River Basin in Central-West Brazil. This application entailed the construction of a simulation model for the regional system and its utilization for the formulation and evaluation of development strategies.

It is necessary to point out that the Integrated Study for the Development of the Upper Paraguay River Basin (EDIBAP) was carried out as a joint programme of the Brazilian Government, the Organization of the American States (OAS) and the United Nations Development Programme (UNDP). The author works for OAS and formed part of the technical staff of EDIBAP, so in writing this thesis he greatly benefited from the interdisciplinary environment provided by EDIBAP and by the great variety of studies carried out by high-level Brazilian specialists and experts of the international organizations involved in the project. However, the opinions expressed in this thesis as well as all the shortcomings of the proposed methodology and of the model and their application to this case study are the sole responsibility of the author.

PART ONE

THE THEORETICAL BACKGROUND

INTRODUCTION

Planning, whatever the field in which it is practised,may be regarded as a way to enhance the rationale of decision-making. As such, society expects that planning should lead to better decisions which in turn will make possible the attainment of a better state of affairs at some time in the future.

As far as this thesis is concerned, attention will be given to the problem of improving decision-making rather than to the process of translating decisions into action.

The quality of decisions is basically determined by the level of knowledge available about the characteristics of the system whose structure and behaviour is the subject of planning, together with the degree of rigour with which the decision-making process is applied. This distinction of the elements that underlie any planning exercise is similar to that of Faludi who speaks about "substantive and procedural theories" and to the well-known distinction between "theory in planning and theory of planning" introduced by Harris.

Since the subject matter of this thesis is regional planning the term "substantive theory" will be used here to refer to the set of partial theories and fragmentary knowledge that constitute what may be called the current theory of regional development. Similarly, the expression "procedural framework" is utilized to refer to the set of activities and administrative processes involved in the formulation of regional development plans.

This first part contains the theoretical background of the thesis which is empirically tested in the second part. As such, it presents an overview of the main theories and concepts underlying regional planning practice both in terms of substantive theories and the procedural framework; and defines the "strategy-projects" approach as a means of increasing the efficacy of planning.

This first part is composed of two chapters. Chapter One is devoted to a study of the theoretical foundations of regional planning and the identification of its main methodological deficiencies.

Chapter Two proposes a procedural framework for this activity, consisting of a flexible arrangement of planning normal tasks according to a cybernetic approach, reinforced by the use of computer simulation.

CHAPTER ONE

REGIONAL PLANNING. SOME THEORETICAL ISSUES

1. REGIONAL PLANNING. SOME THEORETICAL ISSUES

This chapter aims to identify some of the deficiencies of procedural and substantive theories of regional planning which could explicate the problems currently being faced by this activity and to explore some ways of overcoming them.

The work is carried out in three sections: one is devoted to the procedural framework, another deals with substantive theories and the third contains some concluding remarks.

The study of the procedural framework starts with the definition of the scope of regional planning and the identification of the part of this professional field to be covered by the study. Then the main features of planning practice in Latin America are briefly reviewed in order to identify its main methodological weaknesses, and three basic decision-making models are studied for establishing their information requirements. Underlying this scheme is the idea that, to the extent that planning is understood as a tool for improving the rationale of the decision making process, planning procedures must lead to a permanent flow of information providing decision-makers with an up-to-date view of the state of the regional system.

The study of the substantive framework, in its turn, consists of a review of the main features of current theories of regional development. Perhaps the greatest problem of such a review is the definition of some criteria for classifying all relevant theoretical formulations. Thus, in order to provide a complete but synoptic view of the state of the substantive framework, Wrobel's typology of regional development theories was adopted as the conceptual guide for this study.

1.1 THE PROCEDURAL FRAMEWORK

This section is concerned with exploring the problems that a rise when applying planning procedures to policy formulation in the field of regional development. A simplified approach for such a study will distinguish problems related to the way in which planning procedures are implemented from those dealing with the definition of the subject matter, namely the field of regional planning. Since the latter has been regarded as a permanent source of controversy, it seems reasonable to begin with a brief characterization of the meaning of regional planning.

1.1.1 The Field of Study

Undoubtedly, the term "regional planning" is understood in different ways by many specialists. This constitutes an additional difficulty for formulating social and economic policies in regional areas, as well as for defining research policies in this field.

In fact, there is some confusion as to whether regional planning refers to the scale at which the planning takes place (national, regional, provincial, local) or whether it relates to the subject matter of planning (global, sectorial, spatial). This problem could be stated as follows: does regional planning have its own subject matter, or it is simply the result of spatial disaggregation of economic and social planning? Although the stating of the problem may appear to be a quibble, it has some features of conceptual relevance.

Analysing the subject of what is commonly known as regional planning, Boisier holds that, "it is defined by social and economic structures spatially shaped, as well as by the way in which these structures interrelate with each other.

It is then the explicit reference to the geographical space and its close associates (distance, mobility, transportation) of the socioeconomic processes and phenomena that define the boundaries of spatial planning" (BOISIER,1975).

In this sense, the region must be understood as a methodological artifice and is defined as an interrelated system of social and economic elements, its action being spread over specific geographical space.

Due precisely to their great complexity, regions must be considered as "open systems" which, at the same time,are subsystems of more general ones (national systems of regions, multinational systems, etc). As regards "subsystems", the structure and functioning of regions are conditioned by the characteristics of the general systems to which they belong.

There are at least two assumptions of importance implied in this conception. First of all, the human community living in a region undertakes social and economic activities in order to reach its goals. These activities compete with each other for certain types of land in specific geographical locations, showing at the same time different spatial behaviour. Social activities utilize certain spatial facilities and as result of their operation,the environment is modified (positively or negatively). In the case of economic activities, utilization of the geographical space is found in two different forms: as a productive factor (agriculture, cattle-raising, forestry, mining, etc) or as a point of localization for its corresponding productive processes (industry, commerce, services,etc).

On the other hand, despite interrelations existing among social, economic and physical (spatial) elements, these elements form a hierarchy whose structure ensures that physical changes are brought about by social and economic requirements.

In this way, human activities operate within the context of a physical structure that can be adapted for the attainment of political, social and economic objectives, which as a whole comprise society's goals.

By means of synthesis, it is possible to characterize regional planning as a "set of actions oriented towards rationalizing the decision-making process that originates and controls the process of social and economic change in a spatial system". (BOISIER, 1976; p. 24)

Having discussed the meaning attributed to regional planning, it is now necessary to determine the jurisdiction or scale at which spatial phenomena will be analysed, as well as the "main problem areas" to be studied.

Since the definition of the jurisdiction or scale is only a methodological artifice, the aforementioned spatial delimitation must be understood as the selection of a relevant geographical area for the sake of analysis or of action , which in no way has a definitive or exclusive character.

In this sense, the traditional geographical areas of planning (national, regional, metropolitan, local) prove to be rather inelastic since, as suggested by Sonenblum and Stern, the relevant area for studying one phenomenon will probably be different from that required for studying some other one. (SONENBLUM & STERN, 1964)

Because of this, it is more convenient to define the activities or phenomena under consideration and then determine which scale is most suitable for dealing with them, rather than give an "a priori"definition of the geographical area subject to study.

An adequate course of action for this is provided by the typology of regional activities given by Kuklinski, who distinguishes four different situations that give rise to regional activities:

"Situation Nº1: A particular country tries to use the resources that could be generated through regional development in order to speed up the rate of economic, social and cultural growth at the national scale.

The main elements of this situation can be detailed as follows:

a) The Central Government promotes the implementation of interregional development plans through a central planning agency;

b) The interregional development plan is designed so as to cover the whole country, frequently within the framework of an overall development plan;

c) Regional development means in this instance the disaggregation of national social and economic policies.

Situation Nº2: The aggregation of local activities generates the activity of regional development in such a manner as to adopt a regional scale for the solution of problems that cannot be dealt with on a local basis (for example, a Metropolitan Government to deal with problems that overcome the municipal scale).

Situation Nº3: In a given country, a special action of regional development is designed and applied so as to accelerate economic, social and cultural change in a particular depressed or underdevelopped area. This action can be brought about through the established administrative structure, or else through a set of institutions created to that effect and lacking a counterpart in more develop ed areas.

Situation Nº4: The activity of regional development is generated as a result of purely sectorial investment decisions. In this case, the primary motivation for regional development is found in sectorial forces". (KUKLINSKI,1967, quoted by BOISIER, 1976, p.30)

Of the four types of situations depicted by Kuklinski, the activities which are of interest for this thesis are a combination of situations Nº2 and Nº3.

From this definition of activities it follows that the most adequate geographical contexts in which to study them are the regional and intraregional ones, which in turn must be understood as complementary to the interregional one.

1.1.2 Planning Procedures

Recent studies of the Latin American planning experience (*) throw some light on its main procedural deficiencies. These are common not only in other geographical contexts but also for regional planning itself.

Perhaps the most critical aspect of planning methodologies lies in the widespread tendency to "blueprint planning" which has almost inhibited what could be termed decision-oriented planning (**).

Blueprint planning has been characterized as the production "of glossy plans and the unswerving execution of proposals they contain" (FALUDI, 1973; p. 131); and its popularity among Latin American planners has to be seen as the consequence of many factors. Among the latter, should be mentioned, the conception of planning adopted, the inadequacy of planning procedures and techniques to deal with the socio-economic reality of these countries and the institutional way of introducing planning into the public administration.

The conceptual framework underlying Latin American planning during the sixties and early seventies is recognized as

(*) See ILPES, 1976; DE MATTOS, 1978; BOISIER, 1979.
(**) See WATERSTON, 1965; MATUS, 1973; FOXLEY, 1975.

having been highly influenced by post-war European planning. This influence basically derives from the type of academic training received by planning teams, which followed quite closely the French, Dutch, and Scandinavian experiencies, (DE MATTOS, 1978).

Having passed through the stage of reconstruction of war damage these countries utilized planning as a tool merely for correcting some anomalies in their economies, since no important structural changes were undertaken. As such, planning was basically inductive (*) and conceived as "an adjustment tool".

The methodological background of this type of planning emphasized the formulation of a plan which would constitute the referential framework to guide and control the behaviour of the economic system. As De Mattos suggests, this experience progressively established a sort of orthodoxy regarding planning procedures which made the plan the central element of the whole process.

The mechanistic application of this type of planning in Latin America has to be regarded as one of the causes of the widespread "plan-minded planning" that characterizes the experience of these countries.

Closely connected with this conception of planning are the planning procedures (or techniques), which also account for a great many of Latin American planning problems.

Planning requires a number of tools for explaining and forecasting the behaviour of the system under study, which also constitute the basis for defining the type of measures to

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(*) The term "inductive" is used here to denote that planning proposals are expected to induce private firms and independent organizations to adopt a given pattern of behaviour. As such it is to be regarded as the opposite of "compulsive planning", where all agents must follow the plan's orientations.

be adopted in order to achieve a set of expected goals. In the case of adjustment and inductive planning, since what is sought is a set of measures to improve the system's performance (not a structural change of the system itself), planning tools (analytical techniques) were developed to serve this objective and their satisfactory use obviously presupposed a certain level of political, social and economic stability.

Without attempting an adaptation to their own socio-economic contexts, Latin American countries adopted the whole package of planning tools used by American and European planners. This meant that analytical techniques created for economic systems where private firms were strong, dynamic and responsible for a high proportion of productive activities were applied to economies where none of these conditions were met.

In fact developing economies not only are highly influenced by government behaviour but are also exposed to important structural changes as a consequence of both the adoption of modern technologies and the development of new productive sectors. In these circumstances development planning has to control a process of rapid structural change and the use of techniques heavily based on extrapolations of the system's past behaviour will surely lead to a low level of efficacy.

There are some examples of this misuse of planning techniques. For instance, the use of complex macroeconomic models, input-output techniques and other instruments that require sound statistical information and also assume constancy of parameters (*) in situations where none of these conditions were satisfied naturally led to questionable planning proposals.

(*) This assumption relates basically to political as well as social and economic stability.

In the specific case of regional planning the extensive use of regional multipliers, interregional input-output analysis, gravity models, etc., constitutes clear examples of the inadequacy of planning techniques to deal with highly unstable systems.

Finally, there is a third source of problems which explains the blueprint planning tendency exhibited by Latin American countries. It concerns the way planning agencies were created and introduced into the public administration of each country.

Although as early as the forties some Latin American countries began to use planning, there was a sort of official reluctance to accept this idea, based mainly on the assumption that there was a strong link between planning and socialism.

It was not until the "Punta del Este Conference" (*)that planning was officially accepted as a tool for promoting national development (**). This acceptance of planning, strongly reinforced by foreign aid agencies, led Latin American governments to set up planning boards either by superimposing a new organism on to the existing administrative structure or by reorganizing some departments of the public administration. Both ways entailed the introduction of a highly technocratic agency into an already highly bureaucratic administration.

The results of such experience are not surprising. On the one hand, planning boards were engaged in producing highly detailed development plans (urgently required for obtaining foreign aid), while the administration continued acting in the traditional way, on the other. This created a

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(*) This conference held in 1961 constituted the starting event of President Kennedy's Alliance for Development Programme.

(**) See DE MATTOS, 1978; and WATERSTON, 1965.

divorce between planners and decision-makers, since plans formulated in such a way were more likely to be the end product of a theoretical exercise than a guide for proper action, (See FOXLEY, 1975; FABER & SEERS, 1972).

On the whole,this approach to planning did not fit the Latin American context, mainly because its application entailed the use of adjustment tools for promoting development where structural changes were needed, and also because of the failure of planners (owing to their theoretical background) to provide adequate proposals to deal with short-term problems.

As mentioned above, these criticisms are also valid for regional planning but in this case planning deficiencies have been compounded by a weaker substantive theory.

In fact, the recognition of regions as "open systems" has important implications for regional planning since it means that many of the elements that foster regional development are beyond the control of regional actors, (SIEBERT, 1969; HILHORST, 1971).

As a result, regions must negotiate with other regions and with the central government in order to obtain the basic external conditions for their development. Since the social welfare and economic growth of a given region are determined in such a way by the external parametric framework, regional authorities and planners have only a limited degree of freedom for formulating development policies.

It follows that regional planning ought to be a very flexible tool for providing decision makers with adequate information for negotiation.

Since negotiation in its turn aims for a compromise between conflicting interests, there is no room for static and highly detailed plans which become obsolete as soon as an agreement about the parametric framework is achieved.

In this perspective some procedural deficiencies of regional planning become clear. These deficiencies have been attributed by some authors to the fact that regional planning is an heterogeneous aggregate of economic planning techniques conceived to serve other purposes, (LASUEN et al.,1974). The inadequacy of regional planning for solving regional problems arises, in this view, from the ambiguous character of its methodology which is the result of a compromise between urban and economic planning.

As in urbanism, inversely to what happens in economics but with similar results, what is relevant for the city (the element) does not apply to the region (the system); regional planning becomes the incoherent aggregation of irrelevant sets of urban planning techniques and the techniques of economic planning which are applied to the region due to the lack of proper techniques.

Although this is a quite radical view of procedural problems affecting regional planning, it focuses on the main issue, namely the need for methodologies capable of providing regional planning with tools for integrating the economic, social, political and physical dimensions of regional reality.

With less scepticism Boisier (BOISIER, 1979) distinguishes three main methodological problems underlying the practice of regional planning in Latin America. These are the absence of suitable planning procedures, the lack of integration between regional strategies or plans with national ones, and the excessively descriptive character of many regional diagnoses.

Further analysis will concentrate on planning procedures since the second of the above-mentioned problems can be regarded as belonging mainly to the scope of interregional planning and the third one has to be attributed primarily to deficiencies in regional development theories. This last topic will be discussed in Section 1.2.

The inadequacy of procedures used by regional planning derives from the fact that a sort of "all-purpose planning process" has been directly applied to this particular field without regard to its own characteristics. As many authors suggest, application of planning (whatever its purposes) generates many activities which form a process. Although the bibliography emphasizes that the planning process is a "continuum" which is presented only for methodological purposes as an interrelated sequence of activities, regional planning practice is full of examples of the rigid application of processes consisting of a series of self-contained and successive stages which lead to the plan as the final product. (*)

As the theory of regional development is imperfect, for the purposes of this thesis an adequate planning procedure will be understood as an assembly of activities (involving the use of specific techniques) capable of fulfilling the instrumental requirements of regional planning, without creating restrictions (additional to those derived from lack of theoretical knowledge) resulting from operational simplifications.

(*) Davidoff and Reiner attribute the weaknesses of planning procedures to a wrong orientation of planning studies. Although they specifically refer to urban planning their view can safely be applied to regional planning.
These authors argue: "It is our conviction that contemporary urban planning education has been excessively directed to substantive areas and has failed to focus on any unique skills of responsibility of the planner... Planning education until now, has paid little or no attention to methods of determining ends and relating ends to means. And although some tools of effectuation are studied, their relation to a planning process is largely neglected". (DAVIDOFF & REINER, 1962; p.114)

Since planning (and obviously regional planning) is primarily concerned with decision-making, any assessment of procedures will necessarily involve the evaluation of the extent to which such procedures satisfy decision-making requirements.

Since a decision (output) may be regarded as the choice of a course of action from several alternatives, the decision-making (process) can be understood as a set of criteria for guiding this type of selection.

Decision-making involves both a set of values and a certain degree of control over the decision-making situation. Values are inescapable elements of any decision and can be expressed as moral statements, statements of preference, of criteria, or of ends; more particularly as goals (DAVIDOFF & REINER, 1962).

The capacity to control the environment, in its turn, relates to the power of decision-makers to determine the future behaviour of some important variables of such environment. It determines the scope of decisions and becomes one of the crucial issues of decision-making with regard to open systems. This is particularly relevant for regional planning which has to provide development proposals for specific regions within the framework defined by national decisions and strategies.

In general terms this question has been stated as: "To what extent can social actors determine what their course will be, and to what extent are they compelled to follow a course set by forces beyond their control?" (ETZIONI, 1967; p.217).

As Etzioni suggests, there are three basic approaches to decision-making that give varying importance to the degree of control over the environment on the part of the decision-maker. These are the rationalistic approach, the incrementalist approach and the mixed scanning one.

A brief characterization of these approaches will be presented below in order to provide a basis for defining planning procedures capable of satisfying regional planning requirements.

1.1.3. Decision-Making Models and Regional Planning.

Rational decision models assume that a rational choice is the one made after evaluating the consequences that would result from all courses of action open to the decision-maker. Selection is then made using a criterion that reflects the objectives being pursued. In accordance with the importance attributed in this conception to the evaluation of all possible consequences resulting from alternative choices , a simplified model for decision-making becomes: "a) the decision-maker lists all the opportunities for action open to him; b) he identifies all the consequences which would follow from the adoption of each of the possible actions; and c) he selects the action which would be followed by the preferred set of consequences", (BANFIELD, 1959;p. 140).

Banfield recognizes that it is almost impossible for a decision to be perfectly rational since there is not enough knowledge (or time) to study even a fraction of the existing options. Nevertheless, a decision can be regarded as rational if the alternatives and consequences are considered as fully as time and available resources permit.

According to this line of thought, a plan is regarded as a decision about a course of action. It follows that the procedure for making a rational plan is essentially the same as that required for any rational choice.

This approach has been criticized because its assumptions are excessively restrictive. On the one hand, a high degree of control over the situation constitutes a basic condition for this view.

Although it can be argued that forces beyond the decision maker's control may be introduced by reducing the list of opportunities open to him, this would constitute a static consideration of such forces and does not invalidate the fact that this approach concentrates on the management of a controlled environment.

On the other hand, the requirements imposed by this model in terms of time and resources for evaluating possible implications of each course of action are so great that it is difficult to find a decision-maker able to afford them.

Finally, this model implies a static formulation of goals which are used as criteria for guiding a rational choice. Constancy of goals derives from a sharp distinction between values and facts (ends and means), without allowing any interaction between them (see LINDBLOM, 1959; and ETZIONI, 1967).

These criticisms are strong enough for not recommending this approach as the decision model underlying regional planning, or for the planning of any complex open system. Although its internal logic has not been questioned so far, the inadequacy of this approach for fulfilling planning requirements lies in its inability to handle situations involving a large number of variables.

As the number of possible courses of action (and of consequences) to take into account rises almost exponentially as the number of variables increases, the complexity of any social system makes it somewhat infeasible to use rational models as a tool for decision-making.

A similar view is held by Lindblom who has written that this "approach has been strengthened by the attention given to, and successes enjoyed by, operations research, statistical decision theory, and systems analysis...
But these advanced procedures remain largely the appropriate techniques of relatively small-scale problem-solving where the total number of variables to be considered is small and value problems restricted" (LINDBLOM, 1959; p. 153).

The second approach to decision-making, the incrementalist approach, also known as the method of "successive limited comparisons" or the "branch method", was proposed by Lindblom as an alternative to rational models (*).

Starting from the fact that decisions can never be perfectly rational due to the impossibility of meeting the requirements posed by rational models, this method tends to adapt decision-making procedures to the "limited cognitive capacity of decision-makers and to reduce the scope and cost of information collection and computation" (ETZIONI, 1967; p. 219).

Basic characteristics of this less demanding model have been summarized in the following set of six propositions:

"1) Rather than attempting a comprehensive survey and evaluation of all alternatives, the decision-maker focuses only on those policies which differ from existing policies.

2) Only a relatively small number of policy alternatives are considered.

3) For each policy alternative, only a restricted number of "important" consequences are evaluated.

4) The problem confronting the decision-maker is continually redefined: Incrementalism allows for countless ends-means and means-ends adjustments which, in effect, make the problem more manageable.

(*) A first version was presented in LINDBLOM, 1959; further developments may be found in BRAYBROOKE & LINDBLOM, 1963, LINDBLOM, 1965, and others.

5) Thus, there is no one decision or "right" solution, but a "never-ending series of attacks" on the issues at hand through serial analyses and evaluation.

6) As such, incremental decision-making is described as remedial, geared more to the alleviation of present, concrete social imperfections than to the promotion of future social goals" (ETZIONI, 1967; pp. 219-20, extracted from LINDBLOM, 1965; pp. 144-8).

This approach disregards the idea that values (goals) should be defined in advance of the examination of alternative policies, since it is recognized that to a great extent values and facts (ends and means) are closely related (*). It follows that by virtue of not having a permanent element against which decisions could be compared, the branch method relies upon "agreement" as the basic measure of the quality of decisions.

The incremental approach drastically reduces the amount of studies required for decision-taking by the limitation of policy comparisons to those policies that differ to a relatively small extent from policies currently in effect. The final distinctive element of this method is that comparisons, as well as the choice of policy, proceed in chronological series.

(*) Davidoff & Reiner reinforce this idea saying:

"The separation of fact and value in itself requires certain assumptions and possibly violation of the dictates of reason. Let us consider some of the ways in which fact and value may be related:

1) Factual statements and their analysis invariably reflect the values of their makers, if only in the importance attached to them or the sequence in which they are studied.
2) Our personal experiences show that our values are colored by our understanding of facts.
3) We can make factual assertions about values, for example their distribution in a given group. Conversely, one can make value assertions about facts, as does the city planner who desires to counter the fact of public apathy about a public program". (DAVIDOFF e REINER, 1962; p. 167).

"Policy is not made once and for all; it is made and re-made endlessly. Policy-making is a process of successive approximation to some desired objective in which what is desired itself continues to change under reconsideration" (LINDBLOM, 1959; pp. 164-5).

There are many criticisms of this method and suprisingly, they are devastating. The violence of the criticisms can be explained by Lindblom's claim to present incrementalism as a normative model for pluralistic societies as opposed to the master planning of totalitarian societies (ETZIONI, 1967; FALUDI, 1973; BOULDING, 1964).

Criticisms are centered upon two major issues: the first one concerns the replacement of "validity" by "agreement" as the criterion for decision-making, while the second one deals with the conservative character of decisions based primarily on small variations of existing policies.

Lindblom argues that the root method (rationalistic approach) is based on agreement about the ends pursued since "objectives themselves have no ultimate validity other than they are agreed upon" (LINDBLOM, 1959; p. 160). Since a controversy about ends would necessarily entail a good deal of philosophical debate without there being any guarantee that an agreement could be reached on such terms, Lindblom shifts the argument to a field where agreement can be found, namely to concrete policies.

Critics argue that as political or economic power is unevenly distributed among citizens, decisions adopted by consent among partisans would represent the interest of the most powerful, while demands of the under priviliged and politically unorganized would be under-represented (ETZIONI, 1967).

The other line of criticism emphasizes that the way in which the incrementalist adopts decisions invariably leads to the avoidance of decisions involving fundamental changes since they focus primarily on the short run and on a few marginal changes to existing policies. The central point here is whether or not a series of small incremental decisions could lead to "large or fundamental" decisions involving major social changes. Although it is possible to conceive of cases in which this situation does occur, incremental decisions in such cases, can be viewed as following a definite path set by a strategy leading to the fundamental change. It follows that either incremental decisions are defined within the context set by the implicit strategy (which in itself constitutes a fundamental decision), or they lead to the major change by chance.

Since this approach does not contain any specific procedure to ensure that further decisions will be adopted in the right direction, Boulding's opinion that according to the incrementalist approach "we do stagger through history like a drunk putting one disjointed incremental foot after another", seems pertinent (BOULDING, 1964; p. 931, quoted in ETZIONI, 1967; p. 221).

Adoption of this model as an implicit decision-making framework for regional planning would imply a sort of "evolutionistic view" of regional development. Regional development is basically the end product of continuous changes in the structure of regional economies (i.e. the introduction of new branches of industry, increasing the range of export industries, etc.), or changes in the status of regions as a result of their obtaining a different position with regard to public investment, etc. As such, regional authorities are frequently required to engage in major negotiations aimed at creating external conditions that would improve the prospects for development for their regions.

It follows that a decision-making approach relying too much on existing policies would seem inadequate for fulfilling the requirements of policy-making on this scale. Although it can be used for a good many administrative decisions, a complementary approach is needed for dealing with structural matters.

The third model is known as mixed-scanning and was proposed by Etzioni as a description of decision-making procedures actually used in many fields and also as a strategy to be adopted for dealing with complex systems. This approach uses the potentialities of rationalistic and incremental models while trying to reduce their weaknesses by defining the context in which each model is to be preferred.

Societal decision-making is seen as requiring two sets of mechanisms: "a) high order, fundamental policy-making processes which set basic directions and, b) incremental processes which prepare for fundamental decisions and work them out after they have been reached" (ETZIONI, 1967; p. 223).

As such, mixed-scanning endeavours to use a rationalistic approach to study all the major alternatives open for fundamental decisions but avoids concerning itself with details in order to make an overview feasible. Incremental decisions are made within the framework defined by fundamental ones. Although this procedure does not eliminate the possibility of missing an important course of action (only a limited number of alternatives are taken into account), it is less likely than muddling-through to disregard an obvious non-traditional policy and more efficacious than the rationalistic models since detailed considerations are avoided for minor decisions and for fundamental ones analysis is simplified.

Scanning can be performed at many levels (not only two) depending on the complexity of the system under consideration, and the efforts (resources) allocated to each level may vary according to circumstances.

"Effective decision-making requires that sporadically, or at set intervals, investment in encompassing (high-coverage) scanning be increased to check for far removed but "obvious" dangers and to search for better lines of approach" (ETZIONI, 1967; p. 224). These periodic reviews may induce new fundamental decisions providing mixed-scanning with a built-in mechanism for exploring longer-run alternatives.

This model assumes that decisions can be evaluated although evaluation is not performed as fully as in the rational approach. It is recognized that a policy may serve simultaneously one primary goal and a number of secondary ones, or it can be assessed against the achievement of a small number of primary goals. Evaluation then proceeds by means of simple ranking procedures which allow the construction of numerical indexes either entailing an informal scaling of values (the former case) or giving identical weight to all the primary goals (the latter case).

Finally, since allocation of resources for scanning at different levels is left to the decision-maker's judgment, this model is flexible enough to be adapted to situations which may differ in terms of the decision-maker's capacity to control the system as well as the effectiveness of the initial decisions adopted. In fact, a highly incremental approach is to be preferred for stable systems, where previous decisions were yielding adequate results, and in situations where the control capacity is limited. Conversely, a more rationalistic model is required in the opposite situation.

These elements enable Etzioni to conclude that "there seems to be no one effective decision-making strategy in the abstract , apart from the societal-environment into which it is introduced" (ETZIONI, 1967; p. 228).

To the extent that this model stands midway between pure rationalism and muddling-through it benefits from their potentialities and also shares some of their weaknesses. As has been mentioned, the limitations of rational and incrementalist models are significantly reduced in mixed-scanning by defining the context in which each is to be applied. It must be recognized, however, that this model is still far from perfect.

The three types of model presented differ among themselves in the power position assumed for decision-makers, as well as in the procedure to be followed. In terms of regional planning rationalistic models seem unpractical while incrementalist ones are regarded as conservative and short-run oriented. Mixed-scanning appears to be the most satisfactory of them all, since it can be easily adapted to the morphological characteristics of regional development, and also to the type of considerations that regional authorities are constantly required to take into account.

As pointed out by Faludi, this third approach also "includes the acceptance of elements of risk which action involves and thus complements a view of man as stamping his image on an uncertain world, transforming himself during the process and deriving the impetus for yet more learning and growth from the unintended consequences of his actions" (FALUDI, 1973 ; p. 124).

Before discussing specific planning procedures for fulfilling regional planning requirements, it seems necessary to have a quick look at the strengths and weaknesses of substantive theory. Thus, an appraisal of the state of regional development theories will be presented in next section, leaving for Chapter 2 the task of deriving specific planning procedures from a joint consideration of substantive and procedural aspects of regional planning.

1.2 THE SUBSTANTIVE FRAMEWORK.

Regional planning was characterized in Section 1.1.1. as a set of actions oriented towards rationalizing decision-making with reference to the process of social and economic change in a spatial system. Accordingly, it follows from this that the obvious subject matter of regional planning is the comprehensive development of spatially defined systems, whilst a theory of regional development will constitute its substantive framework. The terms substantive framework or theory will be used here to refer to the set of partial theories and fragmentary knowledge usually known as regional development theories.

1.2.1. Basic Concepts.

The concept of development has received great attention in the social sciences, being traditionally used to denominate a sort of "desired future state" of society. As such, its real meaning is not clearly specified, being usually fully charged with political and ideological values and referring to human activities in practically all fields of social significance (see FRIEDMANN, 1973; and SUNKEL & PAZ, 1970).

The theoretical improvement of the social sciences has increased the comprehensiveness of the concept of development, both by including new variables and by broadening its meaning. For analytical as well as practical reasons, the inclusion of the variable space into the concept of development has acquired great relevance opening onto a broad field of study known as "regional science" (ISARD, REINER), "regional economics" (RICHARDSON, MEYER, BOUDEVILLE), or simply "regional planning" (FRIEDMANN).

A good characterization of the emergence of regional development as a relevant line of thought has been given by Friedmann and Alonso who hold that "While the link between space and planning is as familiar to the urbanist as the link between planning and development is to the economist, the joining of "space" to development is only now coming to be acknowledged as a significant extension of traditional ways of thinking" (FRIEDMANN & ALONSO,1964; p.17).

Although a comprehensive view of society underlies the concept of development, it is in the context of economics that it has been mostly studied. Accordingly, current theories of development are highly economics oriented and this characteristic is also shared by regional development theories.

However, it must be recognized that theories of regional development have incorporated (one way or another) into their subject matter elements such as: the valuation of natural resources as regards their renewable or non-renewable character; environmental improvement and conservation; decentralization and participation; economic growth; integration and national security; urbanization and industrialization, etc.

In spite of this, it must be acknowledged that there are not, as yet, any theories comprehensive enough for regional development or rather, for the inclusion of the spatial va riable as a determinant element of development options open to a socio-economic system. Current theories are mostly par tial, emphasizing the treatment of fundamentally economic variables or centering upon functional urbanistic approa - ches.

This means that in practice social, political and environmental aspects are treated as by-products of either economic growth or physical development, whichever happens to be the basic reason for planning.

1.2.2 A Typology of Regional Development Theories

Although the aforementioned lack of comprehensiveness of regional development theories may be regarded as their major deficiency, it is necessary to provide a closer charac terization of such theories in order to analyse their strengths and limitations.

In doing so, a selection of relevant theories is required, since in Section 1.1.1 the subject matter of this thesis was defined as being restricted to the regional and intraregional scales. This being so, an important body of knowledge, perhaps the most developed in theoretical terms , will be ignored and analysis will be concentrated on theories dealing with the spatial dimension of development.

Any typology of theories involves a danger of oversimplification. However, it seems necessary to run such a risk in order to obtain an overview of the state of current knowledge on the subject.

There are many classifications of theories and models of regional development, each of them constructed to serve specific purposes and based on different criteria (*).Due to the similarity of objectives and also because of its analytical rigour, Wrobel's typology seems to be the most appropriate for the purposes of this thesis. This author concentrates exclusively on theories that explain regional growth differentials and proposes a fourfold classification of the numerous theoretical works on the subject.He distinguishes:

"1) "Economic base" type models and related "stages of growth" models, designed to explain how a region grows,

2) Regional income inequality models, explaining how growth is transmitted between regions,

3) Constructions based on the concept of "poles of growth",

4) Center-periphery model developed later into a "theory of polarized development" (WROBEL, 1971; p.3).

A brief summary of the basic features and limitations of such theoretical bodies is presented in the following pages.

The economic-base theory or export-base theory (**) distinguishes two groups of activities in any particular regional economy. In terms of the market area which each economic activity serves, this theory defines the "export or basic sector" as an aggregate of those productive activities producing to satisfy regional, as well as, interregional demand. "Domestic, non-basic or secondary sector", on the other hand, refers to all those activities producing for the regional market.

(*) See for example, FRIEDMANN, 1973; FULLERTON & PRESCOTT, 1975; HOLLAND, 1976; WROBEL, 1971; etc.

(**) NORTH, 1955; TIEBOUT, 1956; HOCHWALD 1958;ISARD, 1960.

This theory postulates that regional growth depends on the behaviour of the export sector, North summarizes the dynamic role of the export sector as follows:"... The success of the export base has been the determining factor in the rate of growth of regions ... The importance of the export base is a result of its primary role in determining the level of absolute and percapita income in a region, and therefore in determining the amount of residentiary,secondary and tertiary activity that will be developed" (NORTH, 1955; in FRIEDMANN & ALONSO, 1964; p.254).

This approach to regional growth problems has been developed further, and constitutes the basis for the economic base multiplier and other types of interregional multipliers (see NOURSE, 1968; Chapter 7).

Closely connected with this line of thought is the theory of economic sectors, which emphasizes the role of internal determinants of regional growth. It was established on the basis of Clark's empiric observations about the relationships between the sectoral structure of employment and the level of income per capita.

Starting from the premise that productivity as well as income-elasticity of demand for industrial goods and services are higher than those for the primary sectors, this theory holds that regional growth is basically explained by changes in the relative importance of different economic sectors (CLARK, 1951; PERLOFF et al., 1960). This type of reasoning finds its expression in a model of economic growth consisting of a sequence of five interrelated stages.

Similarly to Rostow's stages of economic growth (ROSTOW , 1960), regional growth has been understood as a gradual process characterized by the following sequence: 1) subsistence economy; 2) growth through exports of primary goods; 3) growing expansion and diversification of an export base by the development of secondary activities; 4) greater industrial diversification based on internal industrial linkages and growing income; and 5) a widely diversified economy, including highly specialized services.

This model, originally based on historical generalizations concerning the development of the Pacific North West of the U.S.A., has been criticized as lacking sufficient generality to explain regional development in other countries. From a different viewpoint Holland argues that export-base theory is misleading inasmuch as it assumes that regions will be able to adapt their export structure to that of the rest of the economy, and thus diversify their export and residentiary base in a self-sustaining process. Implicit in this assumption lies the idea that long-run factor mobility would lead to more interregional equalisation of per-capita income and a wider dispersion of production.

This neglects the asymmetry observed in factor flows, with capital and labour outflow tending to be one way and not balanced by counter inflows of direct investment in search of lower costs and more available labour. A peripheric region may never achieve a breakthrough from agriculture to higher income and productivity in non-agricultural activities on a scale sufficient to ensure a convergence of regional income levels without significant government intervention (HOLLAND, 1976; p. 90).

Export-base theory has also been critized because it explains regional growth in terms of the behaviour of exports, which is merely "one aspect of a general theory of short-run regional income determination" (TIEBOUT, 1956), and because it is demand-oriented, thereby neglecting to consider the supply side as a determinant of regional income (SIEBERT, 1969).

The second line of theoretical thought, referred to by Wrobel as the "regional income inequality theory", is based on the notion that unbalanced regional growth is inevitable and constitutes a basic condition for growth itself.

Although for many authors the roots of unbalanced growth theories may be found in Weber, Myrdal, Perroux and Hirchman's works, Holland claims that they were first developed by Marx in the mid-nineteenth century. The rationale of such a proposition lies in the fact that the concentration of economic activities in social, economic and spatial terms is inherent to the functioning of capitalism. Marx foresaw many problems derived from the rise of capitalism which were later incorporated into the theories of Myrdal and Perroux. As Holland points out "...one of the key factors which Marx grasped was the extent to which the spatial concentration of production in particular areas was not caused primarily by raw material deposits or the need to reduce transport costs but by the sectoral concentration of production" (HOLLAND, 1976; p. 36).

He also saw rural-urban labour transfer as the spatial foundation of the division of labour on which advance in the productivity of means of production is based. " The foundation of every division of labour that is well-developed, and brought about by an exchange of commodities, is the separation of town and country. It may be said that the whole economic history of society is summed up in the movement of this antithesis" (MARX, quoted by HOLLAND, 1976; p. 38).

Another relevant element contained in Marx's work is the effect of migration on labour demand and labour costs in industries where profits, demand for labour and wages are rising.

Without an explicit recognition of Marx's contributions, these topics were incorporated in the works of Myrdal, Perroux and Hirschman. The basis of this line of thought lies in the observation that economic progress does not appear everywhere at the same time and that once it has appeared powerful forces make for a spatial concentration of economic growth around the initial starting points (HIRSCHMAN, 1958). This statement finds support in Weber's analysis of the "agglomeration factor" in the location of industries, which in its turn rests on the Marshallian concept of external economies later developed by Scitowsky (WROBEL, 1971; SCITOWSKY, 1954).

These elements enabled Myrdal (MYRDAL, 1957) and, shortly afterwards, Hirschman to formulate their theories of regional imbalance.

Accepting that economic growth must occur only in some rather than in all areas of geographical space, these authors concentrate on the analysis of the way in which growth is transmitted between regions.

Two counteracting groups of forces are distinguished as constituting interregional relationships. On the one hand, there are "backwash" effects (Myrdal) or "polarization" effects (Hirschman) leading to further accelerated growth of the more developed region at the expense of the backward one. These effects include flows of labour and capital and also trade profits, which tends to reinforce economic growth in the developed region and to reduce growth potential in the other. Myrdal sees these forces as cumulative and strengthened by increasing internal and external economies in the faster-growing area.

On the other hand, "spread" effects (Myrdal) or "trickling down" effects (Hirschman) tend to reduce regional imbalance by bringing the less developed region the benefits of the progress in the developed one. For Hirschman by far the most important of these effects is the increase in the richer area's purchases and investments in the poorer region.

Although the concepts utilized by these authors are identical, there are considerable differences in their analyses that lead to different conclusions (see HIRSCHMAN, 1958;p. 187).

In fact, Myrdal demonstrates the mechanism of the process of "cumulative causation" leading to ever greater differences in the level of economic growth of regions and concludes that "the play of forces in the market normally tends to increase rather than decrease the inequalities between regions" (MYRDAL, 1957).

Hirschman, in his turn, is more optimistic and foresees that the trickling-down effects would eventually overcome the polarization ones, but he recognizes that the achievement of such a state of affairs requires specific economic policies.

These theories have been refined by Siebert (SIEBERT, 1969), who proposes a regional growth model that identifies a number of growth factors affecting aggregate supply and demand in a regional economy.

As Wrobel points out, Siebert's work constitutes the most comprehensive attempt to date to formalize and systematize regional economic growth theory, embracing the field of previous studies on the lines of the economic base approach as well as production linkages and models of regional transmission of growth.

This approach sees regional economic growth in a situation of mixed economic order as the interaction of internal and external determinants (*). Internal determinants of regional

(*) A revised version of Siebert's model, enlarged by the introduction of the behaviour of the public sector, can be found in ORDONEZ, 1977.

growth are basically increments in the availability of productive factors, improvement in applied technological knowledge, and increases in saving and investment propensities, resulting from endogenous changes in the regional situation. The principal external determinants, on the other hand, are the interregional movement of commodities and productive factors (including government investment and expenditure), and interregional transfers of technology. Both internal and external determinants of regional growth can produce positive as well as negative changes in the level of economic activity of a particular region, depending on the direction in which they operate.

The third line of studies on regional development includes a vast amount of work based on the concept of growth poles. Growth pole theory, first formalized by Perroux, is based on a special conception of space. For this author the "static, rigid, three-dimensional conception of space has led to unnecessary pathological evaluations and psychophathic national policies in Europe. To avoid these consequences he proposed that this three-dimensional concept of space should be replaced in economics by a type of abstract, topological space" (LASUEN 1969; p. 138). It refers exclusively to the universe of economic relationships that take place among economic elements and has no connection with three-dimensional geographic space, except for the fact that economic elements are located in it.

These economic spaces can be reduced to three basic types:1) space as the planning area of the decision units, 2) space as the field of forces acting upon the decision units; and 3) space as the field of homogeneous objects.

Perroux's basic idea is that growth does not appear everywhere at the same time, showing itself rather in certain points or growth poles which transmit impulses of growth to the rest of the economy (PERROUX, 1961; p. 155).

The most distinctive elements of this theory are the concepts of the growth pole and polarization. There are many definitions of a growth pole and this concept has also been the subject of varied interpretations. For the sake of simplicity one of Perroux's characterizations will be adopted here. Growth poles (or development poles) are (simple or complex) dynamic units capable of increasing the product, modifying structures, inducing changes in the types of organization, originating economic progresses or favouring economic progress (translated from PERROUX,1961; p. 189).

As such, this concept corresponds to the dynamic sector of the economy (firms) exerting dominance, by means of input-output relationships, over other sectors and firms. It is to be seen as a logical derivation of the second type of Perroux's abstract spaces (LASUEN, 1969; p. 139).

Polarization, on the other hand, is the process by means of which growth of a given firm or industry induces growth in other activities through external economies. It has been frequently associated with the effects described by Myrdal and Hirschman.

Growth pole theory has gained enthusiastic supporters and during the last twenty five years has come to constitute the main inspiration for a large number of regional plans and policies throughout the world. It has also been strongly criticized on theoretical grounds as well as in terms of its applicability, since many policies and plans based on such a theory have proved disappointing. Although the theory was primarily conceived as applying to an abstract space, it has been widely applied to the study of spatial aspects of economic growth.

This has to be regarded as an important source of confusion and controversy since, as Wrobel points out, the rules for the transformation of one kind of space into the other have never been satisfactorily formulated.

The application of the growth pole concept to geographic space owes a great deal to the work of Boudeville (BOUDEVILLE, 1960, 1966). For this author, economic space is linked to geographic space by means of a functional transformation that describes the properties of economic processes.

Hermansen (HERMANSEN, 1969) holds that the interpretation of geographical growth poles as functional growth poles localized in geographic space is more difficult than the primitive concept, since such a concept implies a double polarization, namely functional polarization together with geographic polarization.

Boisier (BOISIER, 1972) goes farther in this respect saying that the punctual interpretation of the concept of pole seems adequate to the extent that the analysis is limited to abstract space, but that when geographic space is considered what is required is an areal interpretation of pole. From this perspective this author argues that geographic points (urban centers) that are able to internalize the effects of polarization for the spatial subsystem they define, constitute a correct translation of the abstract concept of pole to the geographic plane. Such points are known as growth centers. It follows that a growth center is an urban center which contains one or more growth poles and which also fulfils certain conditions that make it possible to preserve for its spatial system the effects of polarization (*).

Lasuen provides a good characterization of the general feeling about growth pole theory and some related concepts when he says that it "... has become an idea in 'good currency'.

(*) A good synthesis of such conditions can be found in LEGNA, 1978.

It is referred to widely in the social sciences,..., and enjoys the privilege of all mythic catchwords: on the one hand, it sounds like a useful concept for social policy; on the other, being loosely defined, it is not easily subject to meaningful tests. When the concept is used in planning, the failures of the policies centred upon it are normally attributed to the ways and means by which it has been implemented, never to the adequacy of the concept itself" (LASUEN, 1969; p. 137).

The attractiveness of presentation of this theory has led to an overestimation of its potentiality for policy purposes. For Holland there are several factors that explain this overestimation which go beyond the advisability of the implementation of growth poles in particular areas (HOLLAND, 1976; p. 50-4). For him, one of the most relevant of these concerns the importance attributed by management to locational benefits. In practice firms try to maximize short-term profits at the cost of other, long-term factors, thus neglecting the theoretical assumption that they will react rationally in the presence of locational incentives derived from a politically-designed growth pole.

A second factor relates to the importance played by external economies in location decisions when compared with other sources of abnormal profits available to medium and large-sized firms. Since the theory relies only on external economies, it overestimates their role as criteria for industrial location.

Finally, the decreasing incidence of transport in total production costs, together with the fact that only a minor proportion of total investment takes the form of investment in entirely new plant (*), leads to the conclusion that the forces attracting firms to a localized growth pole are not so strong as the theory presumes.

(*) Only about one-fifth of total net investment in industrialized economies (HOLLAND, 1976; p. 52)

In spite of all the criticisms and misunderstandings nobody denies the value of Perroux's contribution, but it is a matter of fact that further theoretical development is needed. This situation has been pointed out by Holland when he says that "the tendency to reiterate rather than extend Perroux's initial analysis has led to the claim that the main elements of polarization theory amount to no more than 'enunciations', and in some cases the claim is not without foundation (HOLLAND, 1976; p.50; quoting PARILLO, 1963).

Wrobel's fourth line of theoretical work on regional development deals with the center-periphery model developed later into a theory of polarized development.

The main exponent of this line of thought is Friedmann who tries to find an adequate theoretical foundation for regional planning. For him the most satisfactory theory for this type of planning "is one that would set forth and explain systematic interrelations between development and space, a theory, in other words, of the development process in its spatial dimension" (FRIEDMANN, 1973; p.41).

Friedmann shares with Lasuen a view of development as a process of adaptation of successive sets of innovations. He starts by using Dahrendorf's conflict model of social change (DAHRENDORF, 1959) for explaining development of spatial systems by means of authority-dependency relationships.

Friedmann distinguishes development from growth. The former refers to an "innovative process leading to the structural transformation of social systems", while the latter is understood as a by-product of this complex process and characterized as "an expansion of the system in one or more dimensions without a change in its structure" (FRIEDMANN, 1973; pp. 43-5).

After discussing six conditions favourable to innovation it is concluded that such conditions are generally met by large and rapidly growing urban systems which become "centers of change". Such centers of innovative change in a given spatial system are called "core regions", while the other areas are termed "peripheral regions". The process of development in its spatial dimension is then studied within the framework of the evolving "authority-dependency" relationships between core and peripheral regions, resulting in a hierarchical order of spatial systems.

As its author points out, "this theory treats economic growth as a function of changes in the structures that inevitably limit a system's capacity for expansion and, in the specific case of growth based on the application of science to problems of economic production, also the system's capacity for the continuous generation and absorption of innovations. This formulation assigns a decisive influence to the institutional and organizational framework of society and, specifically to the patterns of authority and dependency that result from the unusual capacity of certain areas to serve as cradles of innovation" (FRIEDMANN, 1973; p. 57).

Undoubtedly Friedmann's contribution constitutes a serious attempt at integrating social, economic and spatial dimensions of development into a general theory. It should be noted, however, that it contains certain flaws. Perhaps the most important shortcoming deals with the lack of integration of this theory with relevant pieces of other theories of regional development. In fact, although Friedmann holds that contemporary regional growth theory (e.g. as presented by Siebert) constitutes a special case of his general theory, the way of integrating both theoretical bodies has not been explained.

This means that Friedmann's theory remains an explanatory (inductive) and too general a construction , which provides a wide view of the elements that intervene in the development process but without answering practical needs. As Wrobel points out, the very concept of development as an innovating process, while demonstrating the obvious inadequacy to deal with regional economic development problems exclusively in economic terms like the efficiency of investments, is in no way connected with the important process of capital formation.

1.3 FINAL COMMENTS

Now that existing theories of regional development have been reviewed in broad outline, an appraisal of the state of the art seems necessary. This is not an easy task since the classification scheme adopted is only a partial one and under no circumstances can it be regarded as comprehensive, nor has the review been exhaustive.

Bearing in mind the partial nature of this review it is possible to agree with Wrobel when he concludes that the state of the theory is far from satisfactory. This is proved by the fact that the theory is not able to answer many practical problems, although it might indicate the general orientation of policies and makes it possible, to a certain extent, to avoid some well-known errors in the history of regional development planning.

It is necessary to bear in mind that the adoption of any theory as the substantive one for planning purposes leads to the implicit acceptance of such a theory as the criterion for selecting the variables to be considered as strategic in the formulation of development policies, as well as for defining the instruments by means of which such policies are to be implemented.

In other words, a theory conditions the model of development to be adopted and also determines crucial aspects of the path to be followed in order to achieve the objectives. Consequently, the shortcomings of regional development theories are to be seen as a source of the limited efficacy of regional planning.

In general, it is possible to conclude that a great many of the problems regional planning is facing now can be explained as the consequence of the weaknesses exhibited by substantive theories together with the deficiencies in its procedural framework.

These limitations tend to reduce the planner's capacity to control the systems that constitute the subject of regional planning. This is so because, on the one hand, imperfect knowledge of the structure and behaviour of regional systems will necessarily introduce some uncertainty into the results of planning. On the other hand, deficiencies in planning procedures are responsible for introducing unexpected distortions into regional systems through the instruments used for modifying their structure and behaviour. This means that results of a given set of policies may differ from the expected ones owing to the fact that inefficient procedures might lead to intervention in the system in a different way than was planned.

It follows that a more flexible approach to regional planning is required in order to avoid undesirable end results. Such an approach must include as many feedbacks from implementation to decision-making as possible, in order to enable planners and decision-makers to take into account the experience obtained from previous decisions and actions. To achieve this, "blueprint planning" has to be eradicated and a sort of strategy approach to planning seems to be a reasonable way to overcome some of present problems.

This view of regional planning, developed further in Chapter II, combines the mixed scanning approach to decision-making with the use of simulation techniques (as opposed to optimization techniques) for studying possible reactions of the system to exogenous interventions resulting from policy implementation; it is complemented by the study and formulation of specific investment projects which constitute the vehicle for translating planning proposals into real interventions in regional systems.

CHAPTER TWO

TOWARDS A MORE FLEXIBLE PLANNING PROCESS

2. TOWARDS A MORE FLEXIBLE PLANNING PROCESS

Chapter one explains some of the shortcomings of regional planning resulting from the excessive rigidity of planning procedures on the one hand and the limitation of current theories of regional development on the other. Obviously the problems regional planners face nowadays may be attributed to a combination of both types of factors.

This chapter concentrates on the procedural deficiences of regional planning and proposes a flexible approach based on cybernetics and systems theory that aims at a major integration of planning with the decision-making process. Such an integration is expected to contribute to the increased efficacy of planning by simplifying its procedures and permitting a greater approximation of planners with decision-makers and executives in charge of implementation.

From this angle planning has to be regarded as a tool for the assessment of both structural and incremental decisions and also as a permanent source of new alternatives for action. For this the mixed scanning approach to decision-making has to be adopted as the basic strategy for guiding planning activities.

This chapter is organized in four sections. The first contains a brief summary of the basic concepts of systems theory and cybernetics that constitute the theoretical framework for the approach proposed in the second section. This, in its turn, is a combination of the mixed-programming strategy developed by Chadwick and Hilhorst's cybernetic view of planning.

Owing to the fact that the formulation of development strategies and the simulation of models constitute two basic elements of the proposed planning procedure, sections three and four are devoted to analysing in some depth their meaning and main implications.

2.1 THE FOUNDATIONS OF FLEXIBLE PLANNING

Regional planning has been characterized so far as a tool for improving decisions regarding the structure and behaviour of regional systems. As decisions constitute the first stage of a process of regulation of a system's performance and since they cannot be separated from subsequent action, regional planning is to be seen as the control mechanism of regional systems. Thus any attempt to improve its performance will require some knowledge of the structure and functions of such a control mechanism as well as the relationships that exist between the regional system and its control system.

The theoretical background for studying the control or regulation of complex systems is to be found in systems theory and cybernetics.

Systems theory has been defined as the science of totality. In fact, the recognition that the whole is bigger than the sum of its parts means that there are some characteristics of complex systems that are not present in their components. This idea constitutes the leitmotiv of systems thinking which has emerged as an attempt to overcome the incapacity exhibited by isolated causal series and by partial approaches to solving theoretical problems (especially in the bio-social sciences), as well as practical problems raised by modern technology. (V. BERTALANFFY, 1950).

For this author general systems theory is to be seen as an extension of an organic conception of science. It is a conception that emphasizes the study of certain phenomena as the result of a dynamic interrelation of objects and events the behaviour of each being subject to specific laws.

Boulding provides a clear characterization of the scope of General Systems theory and its relationships with other disciplines. He argues that this theory does not seek "to establish a single, self-contained general theory of practically everything which will replace special theories of particular disciplines. Such a theory would be almost without content, for we always pay for generality by sacrificing content, and all we can say about practically everything is almost nothing. Somewhere, however, between the specific that has no meaning and the general that has no content there would be, for each purpose and at each level of abstraction, an optimum degree of generality": (BOULDING, 1956; pp. 198-199).

To the extent that general systems theory aims at the achievement of such a degree of generality, it constitutes an important part of the obvious theoretical framework of planning, which is to be viewed as a general method independent of the particularities of the field within which it is practised.

Cybernetics, in its turn, is concerned with the control and regulation of complex systems. For Beer it is "the science of control and communication - wherever these occur in whatever kinds of system. The core of cybernetic research is the discovery that there is a unity of natural law in the way control must operate, whether the system controlled is animate or inanimate, physical or biological, social or economic". (BEER, 1966; p. 239).

As such, operational aspects of this science are related to any field of study: engineering, biology, physics, sociology, etc. Formal aspects of cybernetics attempt to provide a general theory of control abstracted from all fields of application and appropriate to all of them. (BEER, 1959).

Cybernetics has been especially designed for controlling adaptive, probabilistic and highly complex systems. As such, it is expected to help planning to deal with complexity and to provide adequate control mechanisms for each type of system.

The next sections contain a brief review of some basic concepts of systems theory and cybernetics that constitute the core of the conception of planning to be presented later.

2.1.1 Basic Concepts of Systems Theory

The obvious starting-point for such a review is to define the concept of system. There are many definitions of systems, each of which respond to specific purposes. Aiming for generality, a system can be defined as "an integrated assembly of interacting elements, designed to carry out cooperatively a predeterminated function". (GIBSON, 1960; p. 58), or as " a set of objects together with relationships between their objects and between their attributes". (HALL & FAGEN, 1956; p. 18).

The definition of a particular system for the sake of analysis is always an arbitrary task, largely governed by the researcher's objectives.

For Chadwick, a system, like beauty, lies in the eye of the beholder, since it is possible to define a system in an infinite number of ways in accordance with the interests of the analyst and his purpose. However, once the interests have been defined in terms of the objects, attributes and relationships, it is possible to develop a rigorous analysis in line with the requirements sought. (CHADWICK, 1971).

Flexibility for defining systems derives from the concept of "resolution level", which is to be regarded as the parametric framework of a system (*). In fact it refers to the level of accuracy required for analysing a system's structure or behaviour. Since the resolution level is determined by the analyst in accordance with his purposes, once it is established the system's essential and marginal characteristics can be defined deductively.

The resolution level of a system can be modified at any time. This leads to a greater or lower amplitude of the system under consideration. When dealing with the concept of amplitude of a system it is useful to remember that a system is defined because it contains interrelated parts or elements and, to a certain extent, constitutes a complete whole in itself. But this entity will surely be part of a number of systems which in their turn are subsystems of bigger systems. (BEER, 1959).

Referring to the "scale" of a system in relation to its parts Chadwick distinguishes:

"1. The environment of a system: the set of all systems other than the one in which we are interested .

2. The system itself: defined at a given resolution level.

3. The subsystems of the system: parts of the whole which display a certain richness of intercommunication which distinguishes them from other parts of the system as a whole, but which nevertheless are clearly part of the "larger" system.

(*) Klir defines the concept of resolution level as "the determination of sets of those values of all observed or given quantities to be taken into consideration, together with a set of those time instants at which we want and we are able to obtain the corresponding values of the quantities". (KLIR, 1969; pp. 40-41).

4. Elements of the system (or components): the "small est" parts of the system, the lowest level of detail which is to be considered: we are interested in their behaviour, but not their structure". (CHADWICK, 1971; pp. 42-43).

Among the subsystems and elements of a system there exists an exchange of materials, energy or information. This exchange may also take place between the system and its environment. It follows that a system is "closed" in relation to its environment if there is no interchange between them. Otherwise the system is to be regarded as "open".

The environment undergoes changes with time. A closed system cannot adapt itself to the modification of the environment; at the most it might suffer internal transformations which are not manifested. It is "dead", its possible evolution being governed by the laws of reaction and equilibrium as considered in the field of classic physics and chemistry. (V. BERTALANFFY, 1950; p. 70).

Conversely, an open system will exchange materials, energy or information with its environment. Because of this it will evolve with its environment (it will survive) although in some cases it could reach a stationary state.

The size of a system is measured in terms of its variety, which is in no way related to its physical size. Variety is a measure of the complexity of a system. It is simply the number of distinguishable elements within a set and depends on the way in which the system was defined. (BEER, 1966). Variety is usually measured by logarithms to base 2, which makes it expressible in bits.

It is very common to find in the literature many different classifications of systems. Obviously any typology responds to particular objectives and is entirely dependent on the classification criteria utilized. Perhaps the most useful for the purposes of this thesis is that proposed by Beer, (BEER, 1959) who uses complexity and the type of behaviour as classification variables.

Complexity is divided into three categories (low, medium and high) and the type of behaviour into two (deterministic and probabilistic). This leads to a typology of six categories of systems. Among these, the highly complex and probabilistic systems are of interest to us, since regional systems are included in this category and, consequently, their control belongs to the realm of cybernetics.

Adaptive systems posses s the capacity to react against changes in the environment in a way that favours the continuity of the systems functioning. Using an analogy with living organisms, systems of this type have been referred to as "viable systems". For Beer (BEER, 1966) "viable systems have the ability to make a response to a stimulus which was not included in the list of anticipated stimuli when the system was designed. They can learn from repeated experiences what is the optimal response to that stimulus. Viable systems grow. They renew themselves... They are robust against internal breakdown and error. Above all, they continuously adapt to a changing environment, and by this means survive- quite possible in conditions which had not been entirely foreseen by their designer".

These properties of viable systems are of great importance for control purposes, since the maintenance of system viability imposes certain conditions that must be satisfied by the control mechanism.

Beer distinguishes three basic attributes of viable systems that cannot be overriden without placing a definite and easily achievable limit on the knowledge that can be obtained from such a system. First of all, systems of this type have the properties listed above only if they are highly complex; they must exist beyond a certain "complexity barrier" to be viable. It follows that to insist on treating them through concepts, models and controls that are deliberately of low complexity is to rob these systems of their viability.

Secondly, viable systems maintain equilibrial behaviour only by multiple contact with whatever lies outside themselves. Hence, if the system is artificially isolated from its environment, it is also deprived of its survival and adaptation capacity. Finally, if one decomposes the system into parts in order to study them, or if the analysis concentrates on the behaviour of bits of the system as if the rest of it did not exist, the system ceases to function or at least begins to behave atypically.

2.1.2 Cybernetics

As mentioned above, cybernetics studies the flow of information round a system and the way in which that information is used by the system as a means of controlling itself.

Many authors (McLOUGHLIN, 1973; BEER, 1959; 1966; PALAO,1976; etc.) emphasize that our society has a terrifying image of control which is usually associated with different forms of coercion and repression. Perhaps this image has been induced by the concept of control as used until recently in the management sciences. In this sphere controlling is understood as implying the "measurement of accomplishment of events against the standard of plans and the correction of deviations to assure the attainment of objectives according to plans", (KOONTS and O'DONNELL, 1976; p. 639).

This widely held idea of control assumes a static view of the objectives or standards pursued, and also that the man ager has enough power to define and enforce the behaviour of the individuals and variables involved. Mainly because of this misconception social scientists have long resisted the idea of control in the context of social phenomena, except for denouncing social inequality and domination.

As Cadwallader (CADWALLADER, 1959) points out, this rejection of the idea of control has also inhibited a more direct application of systems thinking and of cybernetics to the social sciences. Fortunately, this situation has been gradually rectified, thanks mainly to the recognition of the importance of implicit control for governing complex systems.

In fact, fourteen years ago, Beer, referring to the concept of control, wrote "Very soon it was realized that control is not a mandatory exercise, in which people are bullied or things are coerced to operate in a desired way. Rather it is a question of coaxing a system toward optimal performance; or, even better, of arranging for the system to regulate itself", (BEER, 1966; p. 253).

Implicit in the idea of control is the concept of "feedback". Although this concept does nor require further explanation, it is necessary to distinguish between negative and positive feedback.

Negative feedback is an error-correcting mechanism also known as deviation-controlling feedback. This constitutes a basic element of cybernetics and its most classical examples are the operation of the thermostat and of the steam engine governor among artificial systems, and homeostasis in living ones.

Positive feedback is much less familiar. It is a relationship between two or more variables of a system that amplify an initial deviation. The brake system of a car constitutes a good example of this type of feedback, since it amplifies the force applied by the driver until it is sufficient to stop the moving car.

Lange (LANGE, 1969), explaining the process of regulation (negative feedback) in the example of an automatic thermostat, concludes that a steady temperature may be obtained by means of three different methods (or by a combination of them).

These are: the principle of compensation of disturbances; the principle of compensation of deviations; and the principle of elimination of disturbances.

The principle of compensation of disturbances seems to be a simple and quick method for control purposes but it requires a complete knowledge of the relationships between disturbances and the system's performance. This is very difficult to obtain, especially when the complexity of the controlled system increases. The second method only works when there is a difference between the current state of the system and the desired one. In this case the counteracting measures are directly fed into the system, which reacts by reducing (or eliminating) the deviation. The principle of elimination of disturbances implies a full command of the environment. Such a condition is hard to fulfil, which makes it an unrealistic method for designing a control mechanism, except for very special and particularly simple systems.

From a different point of view Palao (PALAO, 1976) argues that control mechanisms can be roughly classified into two broad categories: control mechanisms external to the system controlled, and internal ones.

In the first type, the action of the control mechanism is independent of the system's output; it receives information about the environmental disturbances affecting the system and emits counteracting measures. For an adequate performance this type of control requires three basic conditions.

Firstly it needs a criterion for selecting the relevant information about the environment of the system. Secondly, a perfect knowledge of the internal structure of the system is required in order to discover how the system will react against any external stimulus. Thirdly, it requires a high speed of response to adapt itself to a changing environment. This type of control mechanism is very common in control engineering, but its conditions are increasingly hard to fulfil as the complexity of the system increases.

In the second type, the control device receives information about the deviation of the system's output with regard to the objectives pursued, but not about the nature and intensity of the disturbances that generate such deviations. Corrective measures are based on the deviations, that is to say, on the error and not on its causes.

The requirement for a good performance of these control mechanisms is basically a low time of response not only in the issuing of orders, but also in the carrying out of such orders by the controlled system. Both views lead to similar conclusions, since external control mechanisms may be understood as being designed according to the principles of compensation and/or elimination of disturbances, while internal control mechanisms are to be seen as strongly associated with the principle of compensation of deviations.

Cybernetics, in dealing with the control of adaptive (viable) systems, relies basically upon internal mechanisms of control. The next pages will therefore concentrate on the elements that condition the operation of such devices closely following Beer's line of thought. For exposition purposes the control mechanism is presented separately from the controlled system, although it may be clear that both elements are subsystems of a single viable system.

In general, the process of controlling a system entails the definition of another system that receives information about the state of the controlled system and also generates instructions for modifying its behaviour . Schematically, the controlled system and its control mechanism are represented by independent boxes. (See Fig. 2.1).

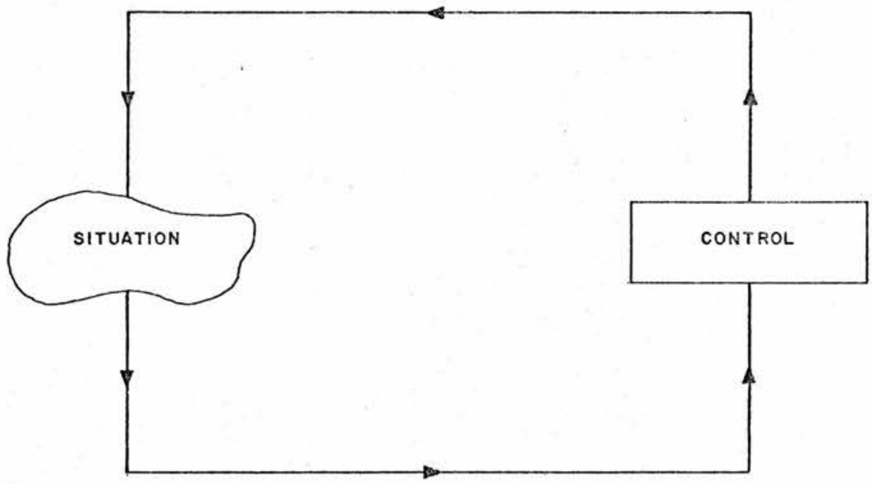

Figure 2.1

BASIC CONTROL LOOP (After Beer, 1966 ; p.276)

Between them there is a channel where information about the state of the system flows towards the control box.The loop is closed by a second channel that transmits to the system orders issuing from the control. The systems we are interested in are relatively isolated, possess a probabilistic pattern of behaviour (as opposed to a deterministic one), are complex and adaptive. Such a type of system has been termed "the situation" by Beer.

To the extent that the situation is a relatively isolated system, it interacts with its external environment. As a result of such an interaction the situation is frequently modified, that is to say, it generates a proliferation of variety (*). Providing that communication channels allow the flow of sufficient information about this proliferation of variety, it is found that control has to deal with a huge amount of information. Beer suggests that there are basically two approaches the control can follow to make good use of this information for regulating the situation. "The first , corresponding to orthodox management practice, declares that a study of this information will reveal patterns and trends in the data, which will enable experienced managers to feed instructions back to the situation through its input loop - and thus to modify its behaviour. The second, corresponding roughly to the position of operational research, is more realistically aware of the magnitude of the problem. It says that the human brain cannot cope with all this information, and that the thing to do is to create an analytical model of what is going on". (BEER, 1966; p. 227). Both approaches are quite similar, the second being a more efficient way of performing the job, since it entails the use of modern scientific techniques. These, however, require all the information to be processed before being able to provide any form of guidance to the situation. Since managers and planners have to deal with real situations where, besides handling the proliferation of variety, they must take decisions (emit orders) with incomplete information, both of these approaches prove to be unrealistic and inadequate.

(*) Variety was defined in section 2.1.1 as a measure of the complexity of a system. Roughly, it accounts for all the states the system may adopt. The proliferation of variety, that is to say, an increasing number of states being possible for the system, makes control a very difficult job. Thus the controller must be provided with tools for containing variety within manageable limits.

In searching for a third approach Beer finds what he calls the cybernetic answer, which is based on the law of requisite variety and on the tenth theorem of the mathematical theory of information formulated by Claude Shannon.

Ashby's law of requisite variety, in its simplest form, states that "only variety can destroy variety". This means that to control a system adequately the control device must be able to generate a variety at least equal to that of the controlled system.

On the other hand, an adaptation to our situation of Shannon's tenth theorem would establish that the capacity of the communication channels that connect the situation to its control mechanism must be sufficient for transmitting all the information produced in each subsystem at its maximum level of variety, otherwise the law of requisite variety is not fulfilled. The same happens if part of the information transmitted is distorted by the existence of "noise" in the channels.

Before discussing the functioning of control according to this cybernetic approach it is necessary to have a quick look at two basic concepts involved in this way of handling the problem.

Firstly, the principle of " completion from without" establishes that "if a system is only relatively isolated (that is to say, open), it has to be absolutely isolated (that is to say, closed) by an artificial convention before its mode of control by the natural laws of cybernetics can be discussed". (BEER, 1966; p. 288). The element that makes possible this artificial closure is known as the "coenetic variable", which is defined as the "common causal determinant of the state of both the environmental disturbance and the situation at the same time ". Although in practical terms this variable constitutes a mere device for closing the system, it also has conceptual relevance. In fact, its existence is the product of the recognition that, although the environment is different from the situation, the latter is part of the environment. Environment and situation have been separated only by a mental act. This means that whatever causes produce environmental disturbances also directly affect the system. Thus the relationships between control, situation and environment can now be schematically presented. (See Fig. 2.2).

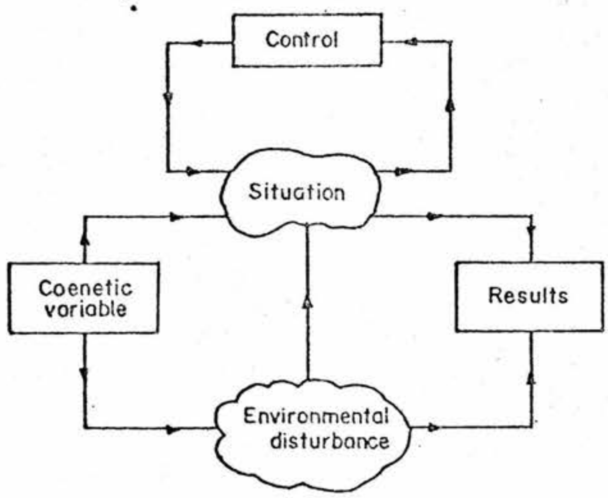

FIGURE 2.2
CONTROL OF AN OPEN SYSTEM (After Beer, 1966; p. 286)

Secondly, cybernetics takes its basic control mechanism from nature. Living organisms regulate themselves by means of "homeostasis", which enables them to keep one or more variables within critical limits, thereby avoiding fluctuations that could generate physiological damage.

When the stability of a system has been disturbed homeostasis also makes it possible for the system to recover its stability or to reach a state (or value) in proximity to its objective. Perhaps the most important characteristic of homeostatic control is that it develops simultaneously with the evolution of the entire system. As Beer clearly explains: "neither biological nor artificial systems employ homeostasis as a control device for the reason that they wish to be static. All the systems in which we are interested intend to learn, to evolve, to become more effective and in general to improve themselves. They do this by making excursions from a state of balance with a given pay-off, and an internal regime for the system which yields a better pay-off that heretofore will be adopted only if it is still capable of achieving a homeostatic steady state", (BEER, 1966;p.289)

Let us examine how the control device works. As has been said, the situation may adopt many states. Control will accept some of these states and will consider the others as unacceptable. Fig. 2.3 shows a cybernetic control loop where the situation and control boxes may adopt any state (represented as any point inside the situation and control boxes), but the desired ones are gathered inside the small circle.

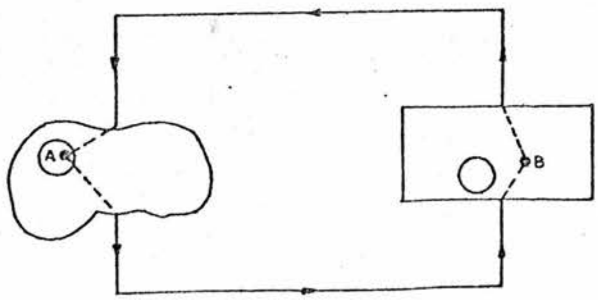

FIGURE 2.3
THE SELF-VETOING HOMEOSTAT (After Beer, 1966, p. 291)

The diagram shows that while in the situation, state A is acceptable, in the control box, state B is not. This subsystem has to decide a trajectory for guiding B to any state inside the circle. Its decision is transmitted to the situation as an order trying to transform state A into another state inside the circle. If everything goes right the transformation operated in the situation will lead point B into the set of desired states from the control's point of view and homesostasis will have been achieved. Let us assume that the initial orders generated in the control box take point A out of the region of desirable states. In this case the situation informs control of the new state of affairs, which in its turn will induce control to alter the planned trajectory, thereby giving rise to new messages. This process, which may be repeated several times, involving the vetoing of control's order by the situation and of the situation's states by control, is known as the "self-vetoing homeostat".

In the event of an external disturbance affecting the situation and altering its internal equilibrium the problem becomes more difficult because the proliferation of variety generated by the disturbance can lead the situation to a state that no one (neither the situation, nor the control) understands. Even in this case equilibrium can be restored since, provided that control has requisite variety, it has the capacity to go on vetoing every unacceptable B, and consequently to force A to change its state (even within its own circle) until B is also acceptable. The time that control takes to reach such equilibrium is important. If it is longer than the average interval between environmental disturbances, the system will be in permanent oscillation.

Having briefly reviewed some basic concepts of cybernetics it is possible to conclude that the systems that constitute the subject of regional planning, as distinct from the people and things they are comprised of, are likely to behave organically. Like living organisms their parts interact so that local objectives are thwarted by incompatible objectives elsewhere. Systems of this type also have the capacity to learn from their own experience, to recognize patterns in their own circunstances and therefore to develop strategies for improving their future behaviour.

The best way to control such systems consists of helping them towards self-regulation, the self-vetoing homeostat being the formal device that accounts for this characteristic. It is necessary to bear in mind that in implicit control mechanisms "arrangements are not made to record every possible state of the system and every best answer to every state. Arrangements are instead made to ensure that the system will be able to find, or to learn to find, the answers to problems it is set", (BEER, 1966; p. 302).

2.2 A "STRATEGY - PROJECTS" APPROACH TO REGIONAL PLANNING

From what has been discussed in previous sections it is now clear that regional planners have to deal with the control of open regions which must be seen as highly complex viable systems with adaptive behaviour.

In dealing with such a system regional planners have to overcome great difficulties arising basically from imperfect knowledge of the system itself and also from a lack of adequate theories for explaining the process of regional development. They also have to manage a proliferation of variety generated by the interactions occurring between regions and the national system of regions to which they belong, and all this has to be done with scarce resources and time. As has been said, the game has to be played in a taxi with the meter running. Under such conditions optimal solutions seem impossible, except by chance.

Although the situation is certainly very complex, planners can devise some tools for dealing with it.

In fact, in these circumstances there is no practical capacity for analysing all possible courses of action; therefore, policies and decisions have to be formulated on the basis of a process allowing for a selective analysis of existing options, that is to say, by means of the mixed scanning approach presented in section 1.2.

Such an approach enables the management of great quantities of information through an iterative process, which, although not guaranteeing optimal decisions, at least reduces the possibility of making serious mistakes. The mere fact that planning proposals may be formulated on the basis of a systematic consideration of all available antecedents constitutes a promising way for improving their efficacy.

From another point of view, from cybernetics we know that the regulation of highly complex systems has necessarily to rely on the system's capacity for controlling itself, and this can be monitored through a self-vetoing homeostat-like device, even when knowledge is incomplete.

This is confirmed by Lowry when he argues that "it is unnecessary to seek the optimal because of people's adaptive behaviour, and that the solution span in practical situations is much more constrained than in theoretical circumstances, so solutions tend to overlap. In short the preparation of plans is an activity system which is bounded by our recognition of the nature of the situation, by the purpose of the plan, by its time scale, and by the resources available both for its preparation and its implementation" (LOWRY, 1965, quoted in CHADWICK, 1971; p. 337).

2.2.1 Current Formalizations of Flexible Planning

Our problem now consists of deriving a planning process starting from a mixed scanning approach to decision-making, systems theory and cybernetics. In doing so, no originality can be claimed since similar, although partial efforts have been made by some authors. Among them, the work of Chadwick and Hilhorst seems most pertinent to the objectives of this thesis.

Chadwick translates the mixed scanning approach to decision-making into his "mixed-programming strategy" in an attempt to provide a flexible view of planning which makes the use of some modern techniques such as modelling, dynamic simulation, network programming, PPBS, etc., compatible with a systematic view of planning.

The mixed scanning approach is used as a means of systematizing planning activities in order to enable planners to process a great quantity of information in their formulation of development policies and projects. As such, the "mixed - programming strategy" is composed of four levels of activities.

The first one, denominated "strategic level of consideration of alternatives", includes the analysis and evaluation of the main alternatives open for decision-making. Such an analysis entails an examination of these alternatives in terms of their political, social and economic feasibility, which naturally leads to the rejection of a good many of them.

This task normally involves the simulation of alternative policies and a selection of the best ones, bearing in mind the objectives pursued and the social cost inherent in each. Here, network programming comes into play. In the case of regional planning at this level, an analysis of the compatibility between each alternative regional policy with the national development policies is performed, which leads to the selection of a regional development strategy.

The second group of activities, called "Pre-Implementation Programme" deals with disaggregating the regional development strategy into specific investment projects and admininstrative actions. In doing so, Chadwick recommends four criteria that should be followed in order to ensure that the implementation of the programme be carried out as intended when it was designed. These criteria (rules) are:

> "1. When possible, fragment implementation into several sequential steps (an administrative rule).
>
> 2. When possible, divide the commitment to implement into several serial steps (a political rule).
>
> 3. When possible, divide the commitment of assets into several serial steps and maintain a strategic reserve (a utilitarian rule).
>
> 4. If possible, arrange implementation so that costly and less reversible decisions will appear later in the process than those which are more reversible and less costly" (CHADWICK, 1971; p. 338).

Thus, the end product of this stage consists of a detailed programme for gradually implementing the selected strategy. Here, PPBS, operations research and other techniques may be used.

The third stage, "Implementation Review Programme or Progress Review" , includes a permanent assessment of implementation. Following the mixed-scanning principles, this stage includes highly detailed scanning for checking the way in which the system reacts to the measures adopted or the projects implemented, as well as wide-angle scanning for evaluating how the strategy works. Both activities may be improved by using some evaluation techniques. Broad scanning will provide useful information for any possible strategy reformulation.

Finally, Chadwick's planning process considers an overall "Programme of Resource Allocation". This programme relates exclusively to resources for studies alone and has no relation to resources for investment projects. It entails the formulation of a rule for the allocation of assets and time among the various levels of scanning that constitute the whole decision process. Chadwick's planning process is schematically presented in fig. 2.4.

Hilhorst in his turn uses basic concepts of cybernetics to explain the way in which the planning of complex systems is to be organized. The systems considered by this author are adaptive and able to modify their own objectives; his approach is thus especially designed for handling high variety and, as such, constitutes a realistic scheme for implementing flexible planning at the regional scale.

The activities involved in the guidance of a system (a region) are performed by various organisms which, grouped together, constitute the "control box" shown in fig. 2.1. Schematically, Hilhorst divides these activities into five basic functions each of which is allocated to a specialized unit. These units are the receiver (R), selector (D), effector (E), memory (M), and the goal's adaptor (P). (See fig. 2.5.).

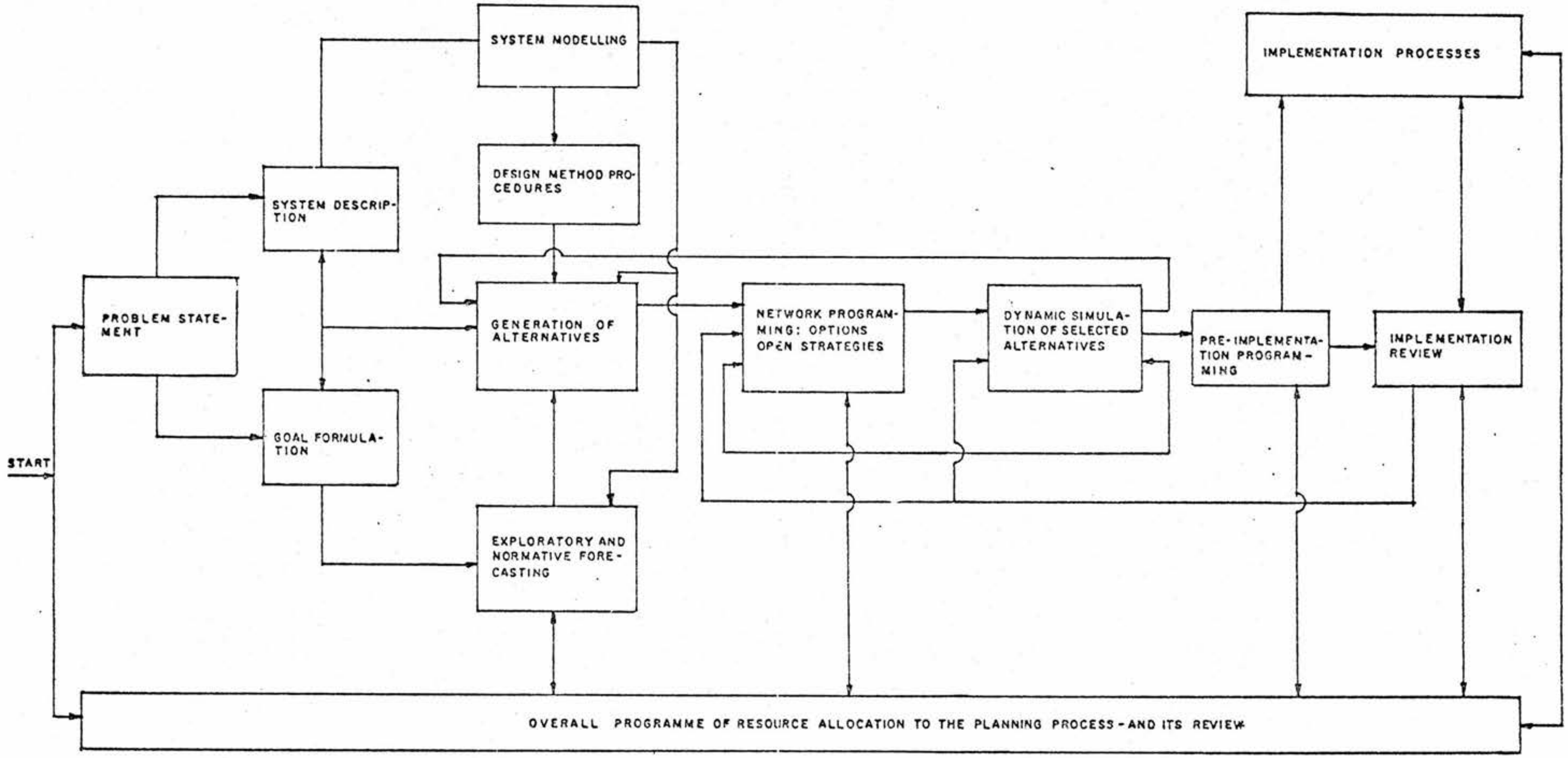

Figure 2.4
THE MIXED-PROGRAMMING STRATEGY (After Chadwick, 1971, p. 349)

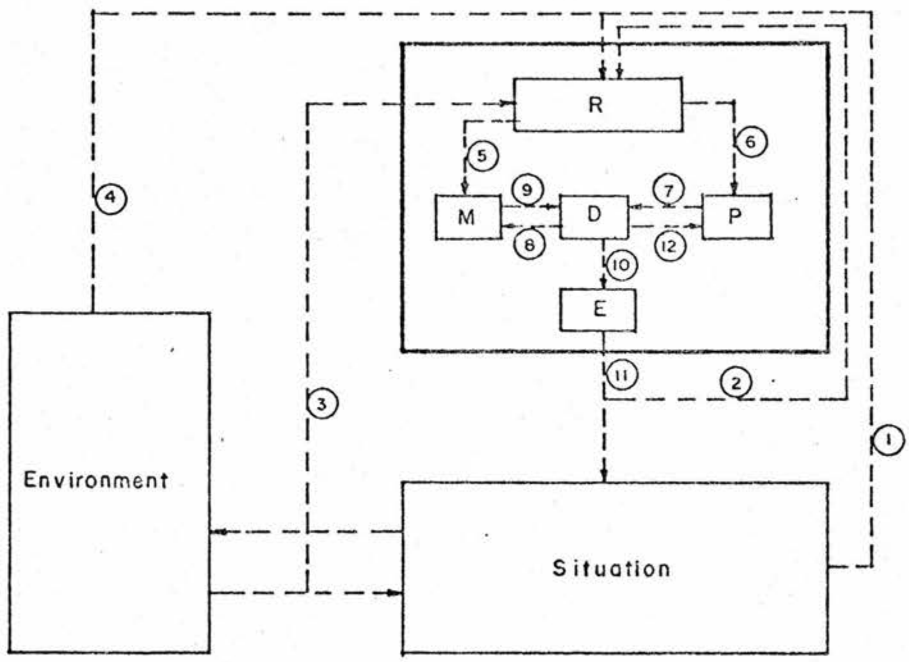

FIGURE 2.5
CYBERNETIC CONTROL SYSTEM (After Hilhorst, 1978; p. 43)

The receiver (R) has the function of collecting, stocking and processing information about the state of the situation, the state of the environment, the interactions between situation and environment, and also about the measures being taken by the regional authorities for modifying the state of the situation.

Information is collected through channels 1,2,3 and 4 (fig. 2.5), processed by (R) and sent to other units in the form of statistics, reports, etc.

The memory (M) is the part of the control system responsible for: i) the formulation of images and models of the situation, including the effects of the relationships between situation and environment; ii) the formulation and evaluation of alternative operative measures consistent with the objectives being pursued; and iii) detailed programming of the operative measures adopted by the selector.

These functions are very broad and correspond in the real world to those to be carried out by a planning agency (in our case the regional planning board). This organism receives information about the state of the situation from the receiver (through channel 5) as well as from other organisms of the regional and national administration (*). Its relationships with regional authorities (selector in Hilhorst's terminology) are very close, receiving from them information regarding objectives, policies, tools, and decisions adopted (via channel 8) and sending them policy and action proposals.

For an adequate fulfilment of its functions, M, besides a good knowledge of the state of the situation (including its interactions with the environment), needs to be aware that there exists a time-lag between the moment in which the information was collected, the moment in which the memory itself is taking notice of the state of affairs, and the moment in which any measure may change the state of the situation.

This is a very important aspect. In fact, the situation is likely to change its state (due to its dynamic and adaptive behaviour) from the moment in which the problems were detected until the time when the situation is effectively affected by

(*) It is necessary to bear in mind that usually regional planning agencies rely heavily upon the research made by local universities and other organisms for improving their knowledge of the situation. To this extent such universities and organisms may be regarded as forming part of the memory.

the counteracting measures adopted. If this happens, action may be oriented towards problems that no longer exist, rendering the measures useless, or to problems of higher complexity, the solution of which would demand another type of action.

In order to avoid such problems the memory has to rely on analytical models for explaining the situation's structure and behaviour (including the cause-effect relationships linking the main variables) and also for forecasting its future states.

The next unit of the control system is the selector (D), which examines the proposals formulated by M and their consistency with the objectives sought and chooses among alternative courses of action. Such a selection is translated into operative instructions to the effector (via channel 10).

In practice D is composed of regional authorities, including top executives of public agencies responsible for policy formulation and decision-making.

Subordinated to D is the effector (E), which comprises all elements involved in direct action. This means the whole administration apart from its top executives. E is the unit in charge of putting into practice the course of action defined by D. It is also the one that intervenes in the situation by means of direct action (via channel 11) and that informs R about the actions undertaken (channel 2).

As the system under consideration is capable of modifying its objectives, Hilhorst accounts for this characteristic by defining a special unit devoted to such a function (P). The exact composition of box P will depend on the characteristics of the system studied. In the western world the functions of the goal's adaptor are performed at the national level by the parliament, the representatives of social organizations such as trade unions, corporation leagues, etc., and other groups and institutions. A similar structure may be found at the regional level although it can take various forms.

P defines the objectives of the system, periodically reviews their relevance and defines new ones. In doing this, the goal's adaptor receives information from R (via channel 6) regarding policy proposals. Another source of information for P derives from its own constituent members who are supposed to be representative of certain segments of the population. As such they incorporate the expectations of different social groups, resulting in a major social acceptability for the objectives established, as well as their periodic modifications. The decisions adopted by P are transmitted to the selector (via channel 7), which either gives instructions to E for immediate action or informs M for further analysis.

The two schemes so far presented constitute serious attempts to make planning compatible with the principles underlying decision-making, systems thinking and cybernetics. Although they require further improvements before becoming operational, they propose a dynamic and flexible view of planning that seems to be more adaptable to the requirements of real-world policy formulation and decision-making than traditional planning processes.

In fact, Chadwick proposes a method for increasing the flexibility of planning activities while Hilhorst describes the organization for guiding complex systems (including the functions of planning), taking into consideration the system's capacity for self-regulation.

2.2.2 The Proposed Procedural Framework

It should be clear by now that each of these approaches constitutes a "blade" of the pair of "scissors" we are searching for. Obviously, what is needed now is to assemble these two blades and discuss how the scissors are to be used for satisfying the requirements of regional planning.

Before presenting an adaptation of these schemes for dealing with regional planning it is necessary to have a quick look at some elements that characterize this activity.

As is well-known, the outcome of regional planning must consist of a set of decisions regarding the way in which available policy instruments will be managed, together with a set of projects involving direct action on the part of the regional administration.

When performing their job regional planners have to be fully aware of the dynamic character of the regional system, the limitations of their capability for controlling the system and the fact that their proposals have to be translated into feasible projects before implementation. Let us examine these aspects in turn.

a) The dynamic character of regional systems is the consequence of their "openness", complexity and adaptive behaviour. Because of this the state of such systems is liable to change in response to a wide range of stimuli. These stimuli can be grouped roughly into three categories:

i) Processes endogenous to the system
ii) Environmental disturbances, and
iii) Implementation of specific policies and actions.

The first type of change-inducing stimuli comprises processes derived from modifications of elements of the system, which through interactions with other elements and subsystems may induce incremental as well as structural transformations of the situation. These processes are difficult to foresee and control, mainly because planners and authorities have only limited and imperfect knowledge of the system and also because of the limitations of the instruments they have for intervening in the system.

Environmental disturbances are generated outside the system and their control is entirely beyond the capacity of planners and regional authorities.

The third type of stimuli to which the regional system reacts constitutes the actions and measures taken by the regional administration. Assuming that the administration behaves rationally such actions and measures are to be regarded as stimuli wholly controlled by regional planners.

Therefore, in guiding the regional system towards a desired future state, authorities and planners can handle only a few instruments with limited effects. The recognition of this situation is very important, since the existence of uncontrollable environmental disturbances and internal processes clearly reduces the degree of command of the system on the part of planners, and this in its turn establishes at least two basic conditions to be met by the regional planning system.

On the one hand, regional planning has to be organized on the basis of the "principle of compensation of deviations" because the incapacity to control the environment and the insufficient knowledge of the system itself renders the principles of compensation and elimination of disturbances inadequate. This means that planning must take the form of an internal control device that maximizes the use of the system's capacity for self-regulation.

On the other hand, effective planning requires some estimates of those uncontrollable disturbances and processes, as well as their probable impact on the system. The availability of these estimates is important not only for making possible the study in advance of possible counter measures but also for reducing the time-response lag. Here, systems modelling and dynamic simulation constitute the basic tools for producing such estimates.

b) The second aspect to be considered deals with the limitations of the planner's capacity for controlling the regional systems, which can be viewed as basically determined by the type of policy instruments available for intervening in such systems.

The concept of policy instruments comprises all laws, norms and regulations the regional government is able to use for orienting the behaviour of the elements of the regional system, as well as all actions it can undertake directly. Siebert (SIEBERT, 1969), working with policy instruments for promoting regional economic growth, concludes that they can be classified according to three different criteria: i) in terms of the determinants of regional growth they affect, ii) in terms of the size of the area over which they are applied, and iii) in terms of the intensity of their interference in the market mechanism. As we are interested in studying the degree of control that regional planners can exercise over such policy instruments the second and third criteria seem particularly pertinent.

In fact, according to the size of the area over which the instruments are to be applied they can be roughly classified into regional and national instruments, and their control can be understood as belonging to the realm of the regional and national governments respectively.

The degree of interference in the market mechanism leads in its turn to the identification of five types of instruments. These are:

i) Direct action by the government. This includes the provision of basic social services, productive activities, normal government activities, etc.

ii) Direct controls. These comprise the control of monetary variables (prices, interest rates, exchange rates, etc.) as well as that of other real variables such as sectoral levels of production, interregional transport, etc.

iii) Indirect controls. The most common instruments of this type are taxation, incentives, purchasing powers, regulating stocks, etc.

iv) Information measures. Instruments of this type tend to influence the decisions of private agents by improving the quality of the information on which decisions are taken.

v) Measures of moral persuasion. These include all types of activities and measures implemented by the government in order to obtain support for its policies.

A combination of both classification criteria would lead to a disaggregation of the five types of instruments already presented into national and regional ones and would define more precisely the type of tools regional planners can avail themselves of for achieving their goals.

The amplitude of the use of each policy instrument at the regional scale is not fixed and depends to a large extent on the capacity of the region for bargaining with the central government. This is also valid for the allocation of certain instruments between the regional and the national governments.

Regional authorities and planners, therefore, not only have to define to what extent and how each policy instrument is to be managed, but must also negotiate with the central government in order to obtain a major control over such instruments, as well as a wider range of action. This is perhaps one of the most important results to be expected from regional planning, since these negotiations define the parametric framework for regional development.

c) Finally, regional planners have to bear in mind that their proposals have to be expressed in the form of feasible interventions in the system before decisions and orders for implementation may be issued. In fact, induced changes in the system's structure and behaviour are to be seen as the outcome of specific actions (investments, administrative measures, special activities , etc.) undertaken either by the public administration or private agents. Therefore, to the extent that proper action constitutes the real stimuli to which the regional system reacts, their identification and study (namely the formulation of projects) becomes one of the central aspects of effective planning.

From an administrative point of view, the organisms in charge of the formulation and implementation of the projects included in any strategy for regional development can be grouped into four categories:

i) Organisms belonging to the central government
ii) Organisms belonging to the regional government
iii) Regional private firms and institutions, and
iv) Private firms and institutions external to the region.

The capacity of regional planners for controlling such organisms varies with the category to which they belong: accordingly, the instruments required for influencing their behaviour may differ from one category to another.

It can be safely assumed that organisms of the regional administration can be fully controlled by the regional planning board. If this is so, planners can undertake or supervise (depending on the organization of the regional government) the identification and formulation of projects and also regulate the issuing of operative instructions for implementation.

In the case of projects under the jurisdiction of central government agencies, regional planners only can negotiate certain technical and political aspects of their formulation whilst assuming a more active role in the implementation process.

The involvement of regional planners in the formulation of projects to be carried out by private institutions from the region varies inversely with the level of development of the region under consideration. As is widely known, regional backwardness is strongly associated with lack of enterpreneurial and technical capacities. The weaknesses of these elements tend to reduce the sensitivity of the regional economy to the effects of traditional policy instruments that operate through the market and also inhibit the generation of innovations and, therefore, of projects. In these circumstances regional development is highly dependent on the capacity of the public sector for inducing new activities, as well as for promoting technological change.

From another point of view, for avoiding interregional leakages a development strategy for a backward region will certainly favour the strengthening of resident firms rather than rely on national or multinational ones for the required level of investment. Such a policy leads regional agencies to engage in the identification and formulation of projects and to develop a strategy for inducing the private sector to carry them out with the financial and/or technical help of the regional government.

These reasons are sufficient to justify a deep involvement of regional planning boards in the formulation of investment projects for the region's private sector.

The role to be played by planners in promoting projects to be implemented by extra-regional firms and institutions is of a different nature. In this case the region must negotiate with foreign firms in order to persuade them to locate their businesses in the area and also to obtain net transfers of capital and technical skills and to minimize the leakages to the rest of the country that such investments may generate.

Thus, planners trying to rationalize and dynamize the process of regional development have to be careful to harmonize direct public action with induced private action, and also to ensure that specific actions and projects are compatible with the general policy framework. This last aspect involves a compromise between two frequently divergent views of development planning, namely the macroeconomic and microeconomic approaches to planning, usually known as "planning from above and planning from below", (GARCIA-AYAVIRI, 1978).

Planning from above is made at the top decision-making levels. It starts from general goals and objectives and entails the formulation of strategies to achieve them, which are further specified in terms of policy instruments and investment projects. It is primarily concerned with balancing the programme of regional investment and also with achieving an efficient allocation of resources. Planning from below, on the other hand, emphasizes the identification of specific investment projects and their study until they reach a feasibility stage. It assumes only partial knowledge of the system's goals as expressed by the objectives of a particular investment project.

Projects are then aggregated into regional plans subject to budgetary constraints.

The harmonization of both approaches gave rise to a special procedure termed "comprehensive investment planning", (See TINBERGEN, 1967). Although this comprehensive view derives from development planning at the national scale, it is highly relevant for regional planning since at this level tools for ensuring the compatibility of specific projects with general strategies are urgently required. Thus, in designing a planning system for dealing with regional development special allowance has to be made for incorporating the formulation and negotiation of investment projects into the set of activities to be carried out by such a system.

To return to the main theme of this section, a joint consideration of the characteristics of regional planning already discussed and the concepts of decision-making, systems thinking and cybernetics reviewed earlier leads us to conclude that effective planning at the regional scale has to be organized on the basis of a flexible arrangement of activities for allowing negotiation with private and external agents, must be strongly connected with the decision-making process in order to obtain a high speed of response and, above all, requires a set of tools that provide it with requisite variety for matching the complexity of the regional system.

As mentioned above, such a planning process may be obtained by combining Chadwick's mixed-programming strategy with Hilhorst's cybernetic arrangement of planning activities, as presented in fig.2.6.

The proposed planning process is organized according to the cybernetic conception of control and is thus composed of three basic elements, namely the situation, the environment and the control.

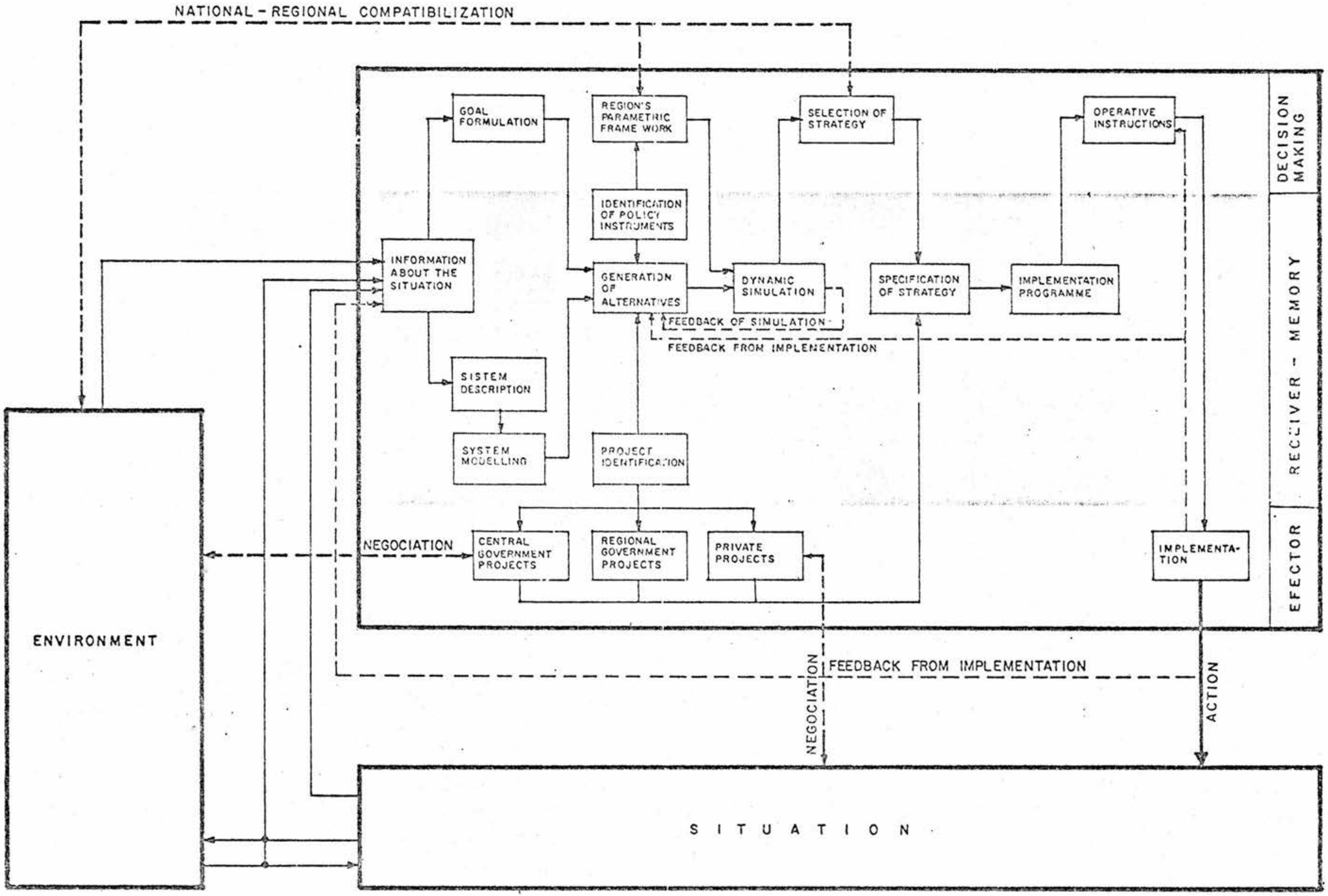

Figure 2.6

THE "STRATEGY - PROJECTS" APPROACH TO REGIONAL PLANNING

The five elements included in Hilhorst's control box are grouped into three administrative levels represented by three sectors of the box. The top part corresponds to the decision-making level and includes the selector and goal's adaptor units. The intermediate sector comprises the receptor and memory while the bottom sector corresponds to the effector.

The solid arrows connecting control, situation and environment are the same as in Hilhorst's scheme (See fig. 2.5).

The process begins with the reception of information regarding the state of the situation, the state of the environment, and the interrelations existing between them.

After processing this information the receiver sends both to the decision makers and to the planning agency. With these antecedents and other information collected, directly or indirectly, goals are formulated at the decision-making level and simultaneously, the situation is scanned and modelled by the planning board, which also engages in the identification of policy instruments available for intervening in the system and in the study of possible projects.

The study of policy instruments may lead to the conclusion that negotiations with the central government may be undertaken in order to increase the regional government's capacity for controlling or intervening in the situation. Such negotiations would lead to a redefinition of the region's parametric framework, which in turn allows the specification of the policy instruments at the command of the regional government and the level at which such command may be exercised, for example, the level of public expenditure and investment, the amount of subsidies to be granted, taxation, etc.

On the other hand, specific projects are identified in accordance with a planning from below approach. The end product of such a task may consist of a list of possible projects which must be further studied by regional agencies or negoti ated with the central government or private firms.

At this stage, established goals, tentative projects and pol icy instruments are used for studying alternative courses of action, which are further analyzed by simulations on the mo del of the situation. After several interactions and feedbacks from simulation this activity may lead to the definition of a set of strategies for regional development. The selection of the preferred strategy is made at the top level of the regional government and may involve some negotiation with national authorities (national-regional compatibilization of strategies).

All these activities roughly correspond to Chadwick's "stra tegic level of consideration of alternative", except that here a special commitment of planners is established for the study of projects and policy instruments.

Once the strategy has secured political agreement, it is further specified in the planning unit. Such specification involves two aspects. On the one hand, investment projects and concrete actions are selected for meeting the requirements of the strategy. On the other hand, available policy instru ments are made compatible with specific projects and actions, which at this stage have already been studied in full detail or negotiated with the organisms in charge of their implemen tation. The specified strategy will, then, consist of a set of projects and actions to be implemented together with the po licy instruments and administrative measures required to car ry them out.

Since the strategy is usually formulated for several years it has to be disaggregated into short-term or annual pro grammes of action, giving rise to budgetary programming and the chronological ordering of actions.

In Chadwick's scheme these activities are included in the "pre-implementation programme" and the rules he defines are obviously valid here also.

The implementation stage includes the issuing of orders for action by decision-makers and their execution by the units belonging to the effector's level. Although a lot of administrative procedures are involved in this process it does not present any important features for planning purposes except for the fact that the time for carrying out such orders has to be minimized for the sake of efficacy.

Implementation gives rise to an important flow of information which constitutes the basic element for improving planning proposals. This flow contains at least three different types of antecedents.

Firstly, information regarding the difficulties that arise when putting projects and actions into operation flows through the dotted arrow to decision makers and planners. Such information may lead to the issuing of new operative instructions or to the reformulation of the implementation programme or even to the exploration of new alternative strategies.

A second type of information concerns the actions and projects being implemented and flows from the action arrow to the receiver as feedback loop external to the control box. These antecedents are used for evaluating the progress of implementation and may therefore induce some modifications to the strategy, implementation programme or operative instructions.

The third type of information is concerned with the state of the situation and its changes arising from actions being implemented and/or environmental disturbances. It is transmitted by the arrow connecting the situation and receiver and constitutes the basic element for evaluating the performance of the strategy and is responsible for major modifications to planning proposals. This evaluation stage corresponds to Chadwick's Progress review and it is here that the criteria derived from the mixed-scanning approach are most directly applied, although they underlie the whole planning process.

As can be easily inferred, the possibility of simulating alternative courses of action open to the regional government through a model of the situation constitutes the main feature of this conception of planning. Dynamic simulation is a quick and easy method both for studying the possible consequences that may result from choosing a particular course of action and for evaluating the impact of specific activities and projects. As such, it is of great help to authorities in negotiations with the central government or other agents, since it allows a quick evaluation of the alternatives and thereby reduces the time required for decision-making.

On the other hand, strategies, when directly linked with the decision-making process, constitute a good substitute for detailed plans which, apart from their rigidity, take too much time in being formulated. The integration of strategies and decision-making requires an efficient system for processing feedbacks from implementation, since incremental decisions have to be adopted on the basis of a good knowledge of the state of the situation (including the changes resulting from previous decisions) and on an assessment of their potential contribution to the strategy's aims. Here again dynamic simulation plays a major role in providing an up-to-date view of the state of the situation and in making possible the assessment of the probable effects of new decisions. In the case of structural decisions new strategies must be studied by going back to the initial stages of the planning process.

It should be recognized that although model simulation provides a good many of the potentialities of this scheme, it also constitutes its major source of weakness. As is known, model building is a difficult job and is highly dependent on the state of the theory utilized for explaining the structure and behaviour of the system under consideration. Thus, imperfect theories of regional development would necessarily lead to imperfect regional models which in their turn would introduce distortions into the strategies for dèvelopment as well as the decision-making process.

Although this is a major criticism it does not invalidate the scheme since shortcomings of regional development theories deeply affect the formulation of detailed plans as well. The right conclusion to be drawn from this is that model simulation cannot be viewed as the end product of the whole planning process but as a mere tool for improving decision-making and that the quality of the information produced by such a tool, may always be judged according to the circumstances. As far as this thesis is concerned the scheme just presented has to be seen as a proposal for a procedural framework for regional planning that would enable this activity to overcome same of the difficulties it is facing now, particularly in Latin America.

Owing to the fact that modelling constitutes the critical part of the whole process, a deeper discussion of this subject is to be found in the following chapters, which contain a model for a particular region and also some simulation experiments in an attempt to show how the model works and how its results are incorporated into the wider planning process.

For the sake of presentation, however, the next two sections of this chapter are devoted to a deeper analysis of the meanning and implications of the concepts of strategy and simulation, which are also important elements of the proposed procedural framework.

2.3 THE FORMULATION OF REGIONAL DEVELOPMENT STRATEGIES

Paradoxically, despite the great popularity that the word "strategy" has lately acquired, only a few authors have referred to it systematically. Because of this, we will first define its meaning more precisely and study its utilization later in the context of regional development planning.

2.3.1 The Concept of Strategy

One of the fields in which most attention has been paid to the concept of strategy is that of games theory where it is characterized as a conditional plan, which indicates a pre-determined decision vis-a-vis any eventuality.

Von Neumann and Morgenstern define the concept in the following way:

> "Let us imagine that the players, instead of making each of their choices at the moment it becomes necessary, consider in advance all possible contingencies, in other words, player k begins to play with a complete plan, stipulating which choice he is to make in every possible situation and for every possible body of current information that he may possess at the moment under the rules of the game. We shall call such a plan a strategy. We observe that the requirement that each player start his play with a plan of this kind in no way restricts his freedom of action. Specifically, we do not force him to make his decisions on the basis of information less complete than he will practically have available at the time of making each move. This is true because the strategy is supposed to specify each individual decision as a function of the exact bundle of information available at the moment the decision must be

made. The only additional obligation our assumption imposes on the player is the intellectual labor of working out a rule of behaviour for all contingencies - although he will actually have to deal only with a few of them".
(VON NEUMANN & MORGENSTERN, 1957).

Inherent to the concept of strategy is the idea that it operates in situations where decisions must be taken bearing in mind the reactions (responses) of the system being affected. Thus, strategies must be formulated in general terms so as to be adaptable to a wide range of circumstances.

The concept of strategy, when applied to the context of socioeconomic development, coincides with the characteristics already presented. It refers to a general and flexible sequence of actions to be carried out in order to obtain a given set of objectives.

Boisier (BOISIER, 1975) holds that in visualizing regional development at the national scale as a situation of conflicting interests between "center and periphery" the situation is very much like a game, particularly the kind of zero-sum (*) game. In this way the conception of strategy deriving from games theory acquires full relevance to the subject of our present concern.

Gilbaud (GILBAUD, 1952) criticises the use of the term strategy when the economic agent faces a passive opponent such as nature. From his point of view, the term should be restricted to cases in which "the player is faced with an active opponent, with a will opposed to his own: an opponent he must fight".

(*) This statement is to be regarded as valid in the short run only especially when the annual allocation of public funds to specific projects is under negotiation. In the long run it does not apply, since the possibility of increasing the productive potential of the economy would surely lead to higher levels of investment capacity thereby enabling both centre and periphery to obtain positive gains simultaneously.

Accepting Gilbaud's viewpoint, development strategies must be understood as a set of general rules for defining courses of action (leading to the achievement of a desired situation), taking into account the reactions of the socioeconomic system to deliberate alterations produced in the system by exogenous decisions (and actions).

Matus has suggested that strategies in the context of development are made up of two basic elements: i) the structure and behaviour the socioeconomic system is desired to achieve in the future and ii) the trajectory, which is a temporal arrangement of actions and projects with a view to attaining such a structure and behaviour of the system in question, (MATUS, 1972).

For our purposes, development strategies constitute wide definitions of the future course of the process of regional development that sets up a group of goals and objectives to be achieved as well as the chronological ordering of actions leading to the attainment of these goals and objectives. Strategies comprise all aspects of regional life and are made up by a coherent set of policies concerned with specific subjects (*).

Since strategies take into consideration the reaction of the system to the actions performed with the aim of modifying its structure and behaviour, they are specific to a particular

(*) A policy is a collection of principles and rules whose objective is guidance of action towards the achievement of determined objectives (See Miller and Starr, 1967, chapter 3 and 4). For our purposes policies relate to specific aspects of development, i.e., polic y of economic growth, employment, technology, etc.

reality (in our case, a particular region at a given time) ; in other words, they cannot be transferred to a different reality without modifications. As such, the formulation of strategies of regional development entails the simulation of the responses of the regional system to an initial set of actions in order to define the subsequent ones.

The development of a regional system, like that of any viable system able to modify its own objectives, has to be seen as an endless process of growth and improvement of its capabilities. This means that, although for practical reasons strategies are formulated for a given time horizon, the final state of the system does not constitute a stationary state. Accordingly, the regulation of this type of system involves a set of decisions to be taken over a period of time and a strategy for such regulation will require a set of criteria for guiding specific decisions taking into account the state of the system and the objectives pursued at the moment each decision is adopted. This is what has been termed an option-open strategy.

This situation can be schematized using Chadwick's adaptation of Kaufmann's decision-chain (KAUFMANN, 1968).

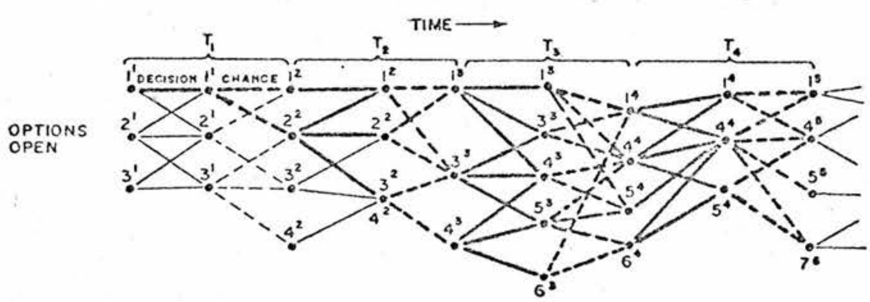

Figure 2.7

GRAPHICAL REPRESENTATION OF AN OPTIONS-OPEN STRATEGY
(After Chadwick, 1971, p. 347)

Fig. 2.7 shows one such strategy as a decision-chain (decision tree) upon a network of other potential strategies. The effects of chance may be regarded as comprising the responses of the system to previous decisions, as well as the effects resulting from endogenous uncontrolled processes and environmental disturbances.

2.3.2 Basic Options for a Development Strategy at the Regional Scale

While strategies contain a set of general criteria that guide the adoption of specific decisions, these criteria are formulated on the basis of an "image objective" previously determined. As such, strategies reflect normative judgement and are consequently subject to ideological influences.

On the other hand, it is necessary to point out that normative judgements determine the form and range in which a set of variables will be controlled or modified, the selection of which is based upon the positive knowledge of the structure and behaviour of real systems.

Accordingly, the formulation of a strategy for regional development depends as much on theories explaining the structure and behaviour of regional systems as it does on a set of normative judgements which determine that structure and behaviour.

As discussed earlier, regional development theories are far from perfect and to a greater or lesser extent reflect an economist's view of regional development, and therefore lead to a partial understanding of and intervention in the system subject to planning. The shortcomings of these approximations have been considered to be responsible for the poor results obtained in Latin America from the implementation of plans for regional development based upon partial theoretical views, (See UTRIA, 1974).

On the other hand, having defined the subject matter of regional planning as the organization of the resulting structure that stems from the spatial conformation of the social and economic subsystems, it is clear that the options to be considered in the formulation of a strategy are physical in character, even though their achievement requires the manipulation of social, economic and political variables.

From the dependence of spatial variables upon socioeconomic ones it can be inferred that the greater or lesser comprehensiveness of the strategy will determine the type and quantity of non-spatial variables to be manipulated. Thus, the basic options (which include judgements of normative character) establish the form and degree in which the behaviour of the independent variables (socioeconomic ones) will be conditioned in order to attain the desired spatial structure.

Boisier states that the formulation of strategies involves an evaluation of the maximum possibilities of change (exogenously induced) that a system can stand. There is a complex technical and political process involved in the evaluation of this limit which from a technical viewpoint, consists of selecting a set of actions from various classical dichotomous alternatives. Leaving aside the global and institutional options (which are decided upon at a national level) , Boisier holds that the truly regional options would be choosing between balanced or non-balanced development, polarized versus non-polarized development (see section 1.2.2), vertical versus horizontal development, etc. (*). This last option refers to

(*) These options derive from the theory of economic growth adopted for explaining regional development. Here planners can adopt a theory of balanced growth as those developed by Nurkse, Lewis, Resenstein-Rodan, etc. or a theory of unbalanced regional growth following Hirschman, Myrdal , Perroux's points of view, (see section 1.2.2).

the choice between reinforcing growth in areas that present some degree of concentration of population, economic activities and infrastructure or stimulating the creation of new growth centres in order to incorporate marginal spaces into production, enlarging, in this way, the production possibility frontier of the economy, (MATUS, 1969).

De Mattos (de MATTOS, 1976) reduces the number of options to three types that are somehow related to the classical dilemma of "efficiency-equity".

Implicit in this approach is the idea that the spatial options consist ultimately of the determination of the degree of geographical dispersion (or concentration) of the population as well as the economic activities most likely to achieve a coherent set of economic, social and political objectives.

Thus, if in strictly economic terms the main objective is to maximize the rate of growth, the most likely spatial option will be the permanence and the strengthening of existing central areas (metropolitan), on the assumption that these do not present an excessive degree of congestion and that there are no structural obstacles to their growth.

On the other hand, an objective such as the reduction of regional disparities (interregional equity) will mean the stimulation of growth in peripheral zones, along with resource transfers from central areas.

There are obviously several intermediate alternatives between these options, a typical case of a third option being the alternative known as "concentrated dispersion".

Finally, it is necessary to remember that the deadline for the attainment of the objectives (the plan's horizon) is an element which may introduce a certain degree of relativity into the relationships described between spatial alternatives and non-spatial objectives. For example, doubling the country's or a region's per capita income in ten years will probably lead to the favouring of investment projects with short maturity periods which can take advantage of existing externalities. Since pecuniary as well as non-pecuniary externalities basically derive from the concentration of population, economic activities and infrastructure , they are spatially concentrated and also present a low level of mobility. Therefore, a strategy relying on the maximization of the use of externalities will surely tend to reinforce the spatial concentration of the system.

If, on the contrary, the objective of doubling income per capita is to be reached over a period three of four times longer than the aforementioned one, it is quite likely that the strategy will emphasize the full use of the potential of available natural resources along with the strengthening of the secondary and tertiary sectors. In spatial terms this may lead to a different scheme for the use of the territory, according to the type, volume and location of natural resources.

The reasons for this sort of incompatibility between short and long term strategies may be found in the different perception of the social cost of overcoming urban congestion and infra structure thresholds which are undoubtedly far more relevant in the long run.

2.4 MODEL SIMULATION

Doubtless, the comprehensive approach of regional planning requires that as many aspects of reality as possible be accounted for. This means that the highly interdependent and complex systems (which are the subject of planning) must be modelled in order to give the planner the opportunity to understand their structure and behaviour. In this type of situation, simulation is a practical solution for handling big and complex models, not only for solving them, but also in order to allow for a great variety of analysis, which will ultimately lead to a better solution of regional problems.

For our purposes, the main contribution expected from the simulation of regional models is to help in the decision - making process in those aspects characterized by a lack of information. A great number of variables must be manipulated in activities such as the formulation of objectives and the definition and evaluation of strategies and development policies (many of them scarcely known) which makes it virtually impossible to analyze them all simultaneously in adequate depth.

The use of models to represent these variables and the possibility of simulating the behaviour of the system under different conditions, will certainly not bring the final solution; it will, however, be a positive step towards improving the decisions taken within the context of these activities.

Simulation techniques seem to be especially important in the formulation of comprehensive strategies of regional development, owing to the great number of variables to be considered and the need to study the possible reactions of the system when faced with interference caused by the actions implied by the different strategic options.

For the sake of clarity some comments on the use of models in planning and the basic characteristics of simulation are presented below.

2.4.1 Models

"Model" has been defined as:

> "a simplified and generalized statement of what seem to be the most important characteristics of a real world situation; it is an abstraction from reality which is used to gain conceptual clarity to reduce the variety and complexity of the real world to a level we can understand and clearly specify".
> (LEE, 1973; p. 7).

As such, models can be understood as an artificial conceptual construction designed to obtain specific information about the main characteristics of behaviour or the structure of a system. Its principal traits are basically defined by two factors: the characteristics of a system to be modelled, and the purposes for which the model is being constructed.

It is necessary to keep in mind that models are not substitutes for the theories on the characteristics or behaviour of the systems that are the subject of planning. Models are based on existing theories and as such they reproduce (and perhaps amplify) the weaknesses of such theories. Many of the limitations of available models are explained in terms of a lack of theoretical development of the disciplines involved.

Since models are auxiliary tools which help the user understand the characteristics and behaviour of real systems, they constitute a great help to planners in their attempts to produce adequate orientations to modify the structure and behaviour of a real system.

Hester (HESTER, 1970) holds that there are two basic objectives in the utilization of models in planning. The first one concerns its use to describe or explain the behaviour of real systems, the control of which will be the purpose of planning. The second objective is related to the use of models to specify the future state of the described systems, so as to anticipate or influence the course of development according to predetermined policies. These two objectives are broad enough to include most of the reasons for the use of models in planning.

However, it is necessary to include a third objective that does not seem to have been sufficiently emphasized by Hester's characterization. This third objective could be defined as the use of models for the purposes of optimization. Planners generally have to spend a great part of their time selecting "the best way" of allocating resources, or the "best strategy" for achieving a definite set of goals. The use of models for this purpose is quite different from the other two objectives and entails a particular type of model (or a particular capacity of models) that, generally speaking, coincides with Lowry's definition of planning models (*).

The advantages of the use of models in planning stem from their main characteristics, that is they constitute a useful tool for increasing the ability to understand the system that is the subject of planning as well as permitting the use of quick and low-cost methods (computers) for solving big and complex problems. Even though the importance of these elements for planning is enormous, it seems unnecessary to discuss in detail their obvious advantages. For the time being, it is more important to be aware of the weaknesses of the models and of the danger of their indiscriminate use in planning.

In addition to the limitations of the models stemming from the theories which support them, it is necessary to keep in

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(*) Lowry maintains that a model can be classified in any one of three categories "depending upon the interest of the client (user) and the ambition of its maker. In increasing order of difficulty these are: descriptive models, predictive models and planning models", (LOWRY, 1965; p. 159) mind that models are imperfect and simplified representations of real systems. As such, they do not contain all the elements (or relationships) that these systems present and the actions or decisions based upon their predictions will therefore probably lead to different results from those expected. Accordingly, the proper use of models requires a full awareness of the conditional character of their results or solutions.

On the other hand, the usefulness of models in planning is seriously limited by the availability of data. This aspect is particularly serious in underdeveloped countries, where the quality and volume of information is generally low.

Finally, Lowry gives us a good synthesis of the use of models in planning. Even though he refers to the use of models to be solved by computers in the specific case of urban planning, tha author points to a more general and relevant problem when he states that:

> "the growing enthusiasm for the use of computer models as aids to urban planning and administration derives less from the proven adequacy of such models than from the increasing sophistication of professional planners and a consequent awareness of the inadequacy of traditional techniques", (LOWRY, 1965; p. 158).

2.4.2 Simulation

Simulation must be understood as a way of using a model. One of the essential characteristics of simulation is exemplified by the observation that a model "represents a phenomenon, but simulation imitates it,... models are photographs and simulations are motion pictures", (ACKOFF, 1962; p.346).

The use of models for simulation purposes requires a particular method of solution which is generally known as "simulation" in the sense that it is different from the analytical solution (LOWRY, 1965). It is utilized when the analytical solution is too expensive or simply impossible to apply. This is quite a common situation, since the conditions required by the analytical solution are frequently so restrictive that the results obtained by such a procedure easily become unrealistic.

The advantage of simulation is that it constitutes the quantitative method that sets up the smallest number of restrictions in the representation of a problem. Practically the only requirement is that the variables be quantifiable and the relationships among variables be defined (HAMILTON, et al, 1969). These characteristics of simulation have made it a useful tool for helping the formulation of policies for governing real world systems.

Although the formulation of policies and strategies for regional systems requires a comprehensive view of the variables involved, it has been in the context of economic policy that simulation has been most commonly utilized. For this reason an economic policy approach will be adopted in order to characterize the theoretical as well as practical implications that simulation imposes on model building, notwithstanding the fact that a regional model aims at comprehensiveness.

Naylor (NAYLOR, 1970) identifies three different approaches for evaluating the effects of alternative economic policies on the behaviour of an economic system. These are the Theil approach, the Tinbergen approach, and the policy simulation approach.

These approaches assume that an econometric model of the economy to be investigated is available.

This model is supposed to be of the following type:

$$"AX_t + BY_t + \sum_{j=1}^{p} B_j Y_{t-j} + CZ_t + D = U_t$$

Where: X_t =an m x 1 vector of exogenous variables

Y_t =an n x 1 vector of endogenous variables

Y_{t-j}= an n x 1 vector of lagged endogenous variables when j=1,..., p.

Z_t =a q x 1 vector of policy instruments

U_t =an n x 1 vector of stochastic disturbance terms

A, B, C, D = coefficient matrices whose parameters have been estimated by standard econometric techniques."

(NAYLOR, 1970; p. 263).

The structure of this model is quite simple. Exogenous variables and lagged endogenous ones are to be regarded as input data for a particular run. Parameters are quantified by means of econometric methods and policy instruments are given precise values either by policy makers or by the research team. The value of endogenous variables constitutes the output of the model and it is highly (and uniquely) dependent on the values assigned to policy instruments.

In this way we obtain in each run the situation (expressed in terms of endogenous variables) the system is likely to achieve as a result of a given policy (represented by a set of values of policy instruments).

From this starting point, Theil assumes as given, a social welfare function of the policy maker which can be expressed as a function of the target (endogenous) variables and the policy instruments:

$W_t = W_t\ (Y_t, Z_t)$

Obviously, the policy maker will try to maximize this function by finding appropriate values for Y_t and Z_t, bearing in mind the constraints derived from the econometric model and the given values of X_t, Y_{t-j} and U_t.

One of the major weaknesses of this approach is the difficulty of defining and quantifying the social welfare function . This problem becomes almost impossible to resolve since, as Naylor points out, "... in the real world we simply do not know the parameters or even the functional form of W_t for governmental policy makers." (NAYLOR, 1970; p. 264).

The Tinbergen approach avoids the problem of maximizing a social welfare function by assuming that the policy maker has specified a fixed target value for each of the endogenous variables (NAYLOR, 1970). Thus, the equations of the econometric model are simultaneously solved for the set of the policy variables Z_t that is consistent with the targets for given values X_t, Y_{t-j} and U_t.

The problem now becomes one of matching the number of policy variables with the number of targets (endogenous variables). Thus, if the number of policy variables is smaller than the number of targets, the quantity of unknowns in the model becomes smaller than the number of equations, and a solution is impossible except in special cases. Inversely, if the quantity of unknowns is greater than the number of targets an infinite number of solutions will be possible.

In the framework of the Tinbergen approach the problem of balancing the number of equations and the number of policy instruments can be solved either by increasing the number of policy variables or by reducing the quantity of target variables until there is an equal number of unknowns and equations in the system.

Although this problem may be regarded as a serious limitation of the Tinbergen approach, Naylor considers another problem to be an even more serious limitation. In fact, Naylor believes that it is very doubtful that policy makers will commit themselves to defining specific sets of target values for the endogenous variables. For this author, this task becomes quite similar to the specification of a social welfare function, although it may prove to be a simpler task.

Finally, there is a third approach to the problem of evaluating the effects of alternative economic policies on the behaviour of the economy. This is the policy simulation approach and it does not assume any prior knowledge of a social welfare function, nor of the targets of the policy maker.

By means of simulation techniques (*) this approach sets out to solve the set of simultaneous equations of the model for Y_t in terms of X_t, Y_{t-j}, Z_t and U_t and to generate the time path of Y_t for a given period of time. The exogenous variables (X_t) are fed into the computer as data. The lagged endogenous variables (Y_{t-j}) are read as input data for the base year and then generated by running the model for the first period and fed back into the model in the next period. Policy variables (Z_t) are specified by the analyst and the stochastic disturbances may either be suppressed or generated by an appropriate computer subroutine (NAYLOR, 1970).

Assuming a linear form for the econometric model presented above, its solution in terms of the policy simulation approach becomes:

(*) Simulation is to be defined as a "numerical technique for conducting experiments with certain types of mathematical models which describe the behaviour of a complex system on a digital computer over extended periods of time. The starting point of any computer simulation experiment is a model of the system to be simulated", (NAYLOR, 1971; p.2).

$$Y_t = -B^{-1} \left[AX_t + \sum_{j=1}^{P} B_j \; Y_{t-j} + CZ_t + D - U_t \right]$$

Here the main difficulty consists of obtaining B^{-1} (the inverse of B). However, given the digital computers available today this operation can be carried out in a matter of seconds.

Since the main aim of this procedure is to help policy makers in the process of policy formulation, two basic questions have to be answered in order to solve a particular policy problem. In terms of Naylor these questions are:

i) What output variables are of particular interest to the policy maker? and

ii) What set of policy variables appears to be politically feasible?

By answering these questions the analyst is able to simulate the model and then show the policy maker the consequences of the proposed policies. This procedure obviously allows experimentation with different sets of policies and, consequently, the attainment of a wide range of alternative policy options.

Finally, Naylor makes a good assessment of the approaches to the policy problem already described in the following words:

> "In summary, while the Theil-Tinbergen approaches may be of considerable interest to economists from a purely theoretical standpoint, neither of these approaches provides operational solutions of policy problems. Therefore, policy simulation experiments may present the only methodology currently available for obtaining practical solutions to real world policy problems."
> (NAYLOR , 1970; p. 265).

This policy simulation approach is similar to Johnson's "General System Simulation Approach" (JOHNSON et al, 1971), which may be regarded as a more general means of solving policy problems. These authors set forth a second equation to measure how well the simulated variables (Y_t) correspond to the real world data (Y^*_t).

$$\theta_{(t)} = f(Y_t, Y^*_t)$$

Where $\theta_{(t)}$ is a set of intermediate output variables which indicates how well the model's outputs represent reality, and corresponds to any of the usual "goodness - of - fit" measures (WILSON, 1974).

There is a third equation proposed in this approach which is used for evaluating different policies. This assessment is made by using a set of output variables which measures the system's simulated attainment of various "goods" and avoidance of various "bads", e.g. profit, income rates of growth, per capita income, unemployment, etc. This proves to be as controversial as Theil's social welfare function or Tinbergen's target variables, and obviously presents similar weaknesses.

For the purposes of this thesis the policy simulation approach will be applied, together with Johnson's procedure for measuring how well the model represents the regional socio economic system. This second element will be used mainly for calibrating and testing the model, and these operations will be carried out separately from the simulations themselves.

PART TWO

THE UPPER PARAGUAY RIVER BASIN CASE STUDY

INTRODUCTION

The second part of the thesis is devoted to the application of the proposed procedural framework for regional planning in a real situation in order to test its potentialities and shortcomings.

This empirical work was carried out within the context of the Integrated Study for the Development of the Upper Paraguay River Basin (EDIBAP) in Central-West Brazil.

EDIBAP is a joint programme of the Brazilian Government, the Organization of American States (OAS) and the United Nations Development Programme (UNDP) (*).

Although the case study presents some limitations (as a result of the institutional and political context that gave rise to EDIBAP) that prevented a comprehensive assessment of the proposed methodology, it did at least make it possible to test the methodology in question on a global basis.

The application of the "strategy-projects" approach to this particular situation entailed both the formulation of a socio-economic model of the regional system and the organization of some of the studies required for the formulation of a regional development plan according to the guidelines of the proposed methodology. This second part of the thesis comprises seven chapters (Chapters 3 to 9) which are complemented by three technical appendices.

Chapter Three is devoted to a general description of the regional system and to an overview of the model.

Chapters Four to Seven contain a technical presentation of the model and of the econometric work done for its calibration.

(*) The author works for OAS and formed part of the technical staff of EDIBAP.

Chapter Eight presents the results of the simulations carried out on the model, both for estimating the future regional situation if no special development policies are undertaken and for quantifying the probable effects of a particular development strategy.

Finally, Chapter Nine is devoted to an assessment both of the proposed procedural framework and of the model's performance. On the basis of this evaluation some ways of improving the "strategy projects" approach are explored.

3. BASIC FEATURES OF A SIMULATION MODEL FOR THE UPPER PARAGUAY RIVER BASIN

This chapter contains a general description of the model, its theoretical foundations and also a rough characterization of the main features of the Upper Paraguay River Basin. This overview of the model and its spatial context is complemented by a brief review of other regional models that heavily influenced this work.

The model is to be understood as an artificial conceptual construction built for the purpose of obtaining specific information about the main features of the structure and behaviour of this particular regional system. Its characteristics are basically defined by the particularities of the Upper Paraguay region and the purposes for which the model was constructed.

As is widely known, modelling is a complex, iterative and sometimes highly intuitive task. It involves empirical observations, theoretical formulations and, above all, requires a great amount of time to be devoted to a trial and error procedure for matching theory and empirical facts. Because of this our model, like any other, cannot be regarded as definitive. Its present form has been judged acceptable for the purposes for which it was designed, bearing in mind the limitations of time, resources and the quality of available information.

For a satisfactory presentation of the model within this particular regional system a progressive way of exposition was adopted. Accordingly, this chapter is restricted to a discussion of the background of both the model and the region, whilst the technical aspects of the model and a detailed consideration of the regional system are presented in subsequent chapters.

This chapter is composed of four sections. The first provides an overview of the Upper Paraguay River Basin and a brief characterization of its recent process of development.

The second section defines the purposes of the model and summarizes its theoretical foundations. Section three is devoted to a general description of the model while section four contains a review of other regional simulation models.

3.1 THE REGIONAL SETTING OF THE STUDY

The "Upper Paraguay River Basin" comprises the northern part of the River Plate Basin, which is delineated by the Paraguay, Paraná and Uruguay rivers. The Upper Paraguay River Basin covers nearly 470,000 square km, 350,000 of which are in Brazilian territory, the rest belonging to Bolivia and Paraguay. The region that concerns us here is the Brazilian part of the basin. Since the borders of administrative territorial entities (municipios) do not coincide with the geographic basin, the study was defined as comprising 46 municipalities with an area of 403,633 km^2. It includes part of the States of Mato Grosso and Mato Grosso do Sul with a population of 1,589,045 in 1980.

The study area's northern and eastern limits correspond to the watersheds separating the Amazon, Araguaia and Paraná river basins. To the south the region borders on the Republic of Paraguay and to the west the Amazon basin and the Republics of Bolivia and Paraguay (see Maps 3.1 and 3.2).

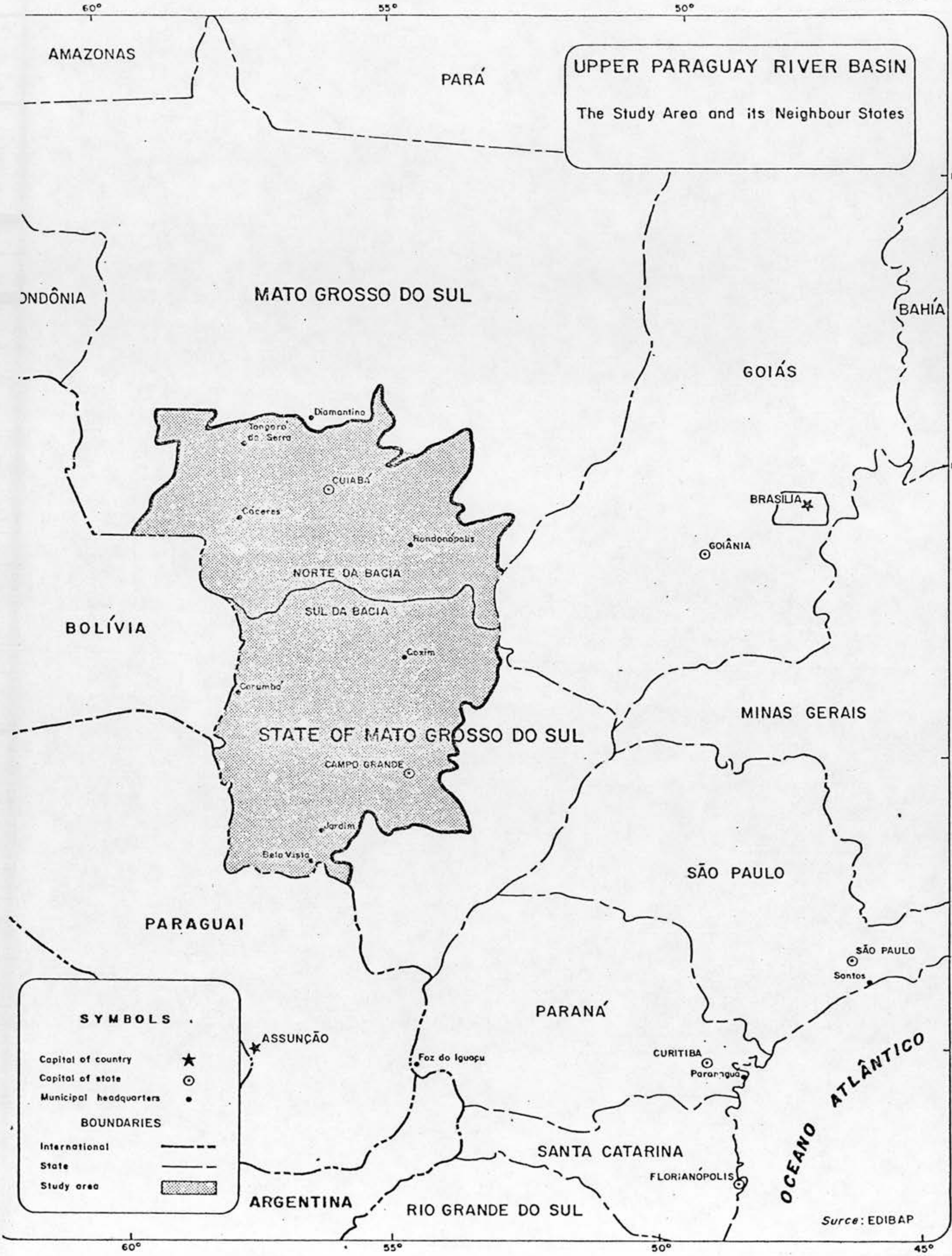
For planning purposes Brazil is divided into five major geo-economic regions which comprise a varied number of states and in some cases territories (*). The study area forms part of the Central West Region which covers the States of Goiás, Mato Grosso, Mato Grosso do Sul and the Federal District. Although we are concerned primarily with the hydrographic basin, for the purposes of the model building and policy formulation a wider reference area including the whole States of Mato Grosso and Mato Grosso do Sul was considered. Two kinds of reason account for the delimitation of this greater area.

(*) A territory is a part of the country that because of lack of population and other political reasons has not yet achieved the status of "state", and is subject to direct rule from the Federal government.

Map 3.1


UPPER PARAGUAY RIVER BASIN
Localization of The Study Area In Brazil
NORTH
NORTHEAST
CENTRAL WEST
SOUTHEAST
SOUTH
Manaus
Belém
Fortaleza
Recife
Salvador
Brasília
Goiânia
CUIABÁ
CAMPO GRANDE
Belo Horizonte
Rio de Janeiro
São Paulo
Curitiba
Porto Alegre
SYMBOLS
Study Area
State boundary
Regional boundary
Main cities
Source: EDIBAP

Map 3.2


UPPER PARAGUAY RIVER BASIN
The Study Area and its Neighbour States
60°
55°
50°
45°
10°
15°
20°
25°
AMAZONAS
PARÁ
MATO GROSSO DO SUL
GOIÁS
BAHÍA
BOLÍVIA
Diamantino
CUIABÁ
Cáceres
Rondonópolis
NORTE DA BACIA
SUL DA BACIA
Coxim
Corumbá
STATE OF MATO GROSSO DO SUL
CAMPO GRANDE
Jardim
Bela Vista
BRASILIA
GOIÂNIA
MINAS GERAIS
SÃO PAULO
PARAGUAI
SÃO PAULO
Santos
PARANÁ
ASSUNÇÃO
Foz do Iguaçu
CURITIBA
Paranaguá
SANTA CATARINA
FLORIANÓPOLIS
ARGENTINA
RIO GRANDE DO SUL
OCEANO ATLÂNTICO
SYMBOLS
Capital of country
Capital of state
Municipal headquarters
BOUNDARIES
International
State
Study area
Surce: EDIBAP

Firstly, the federal system of government in Brazil makes the state the basic unit for public action as well as for the formulation of development policies. In spite of the highly centralized character of the Brazilian institutional system, the state government comprising the Governor, the state assembly and the state counterparts (secretarias) of all ministries is vested with quite important administrative powers and creates a clear "decision-making space" which has to be taken into account for regional planning purposes.

Secondly, the state level is a very important unit for data collection, especially information related to regional accounting (public expenditure, taxes, exports, imports, etc.). In addition, the basin was initially divided into eight programme areas and this spatial disaggregation oriented the work carried out by the project team. Since eight observations were too few to be a significant cross-section it was deemed necessary to introduce four new programme areas comprising those areas of both states not forming part of the river basin (see Map 3.3 and Table 3,1). Thus the study is concerned primarily with the Upper Paraguay River Basin and secondarily with the whole area of the States of Mato Grosso and Mato Grosso do Sul.

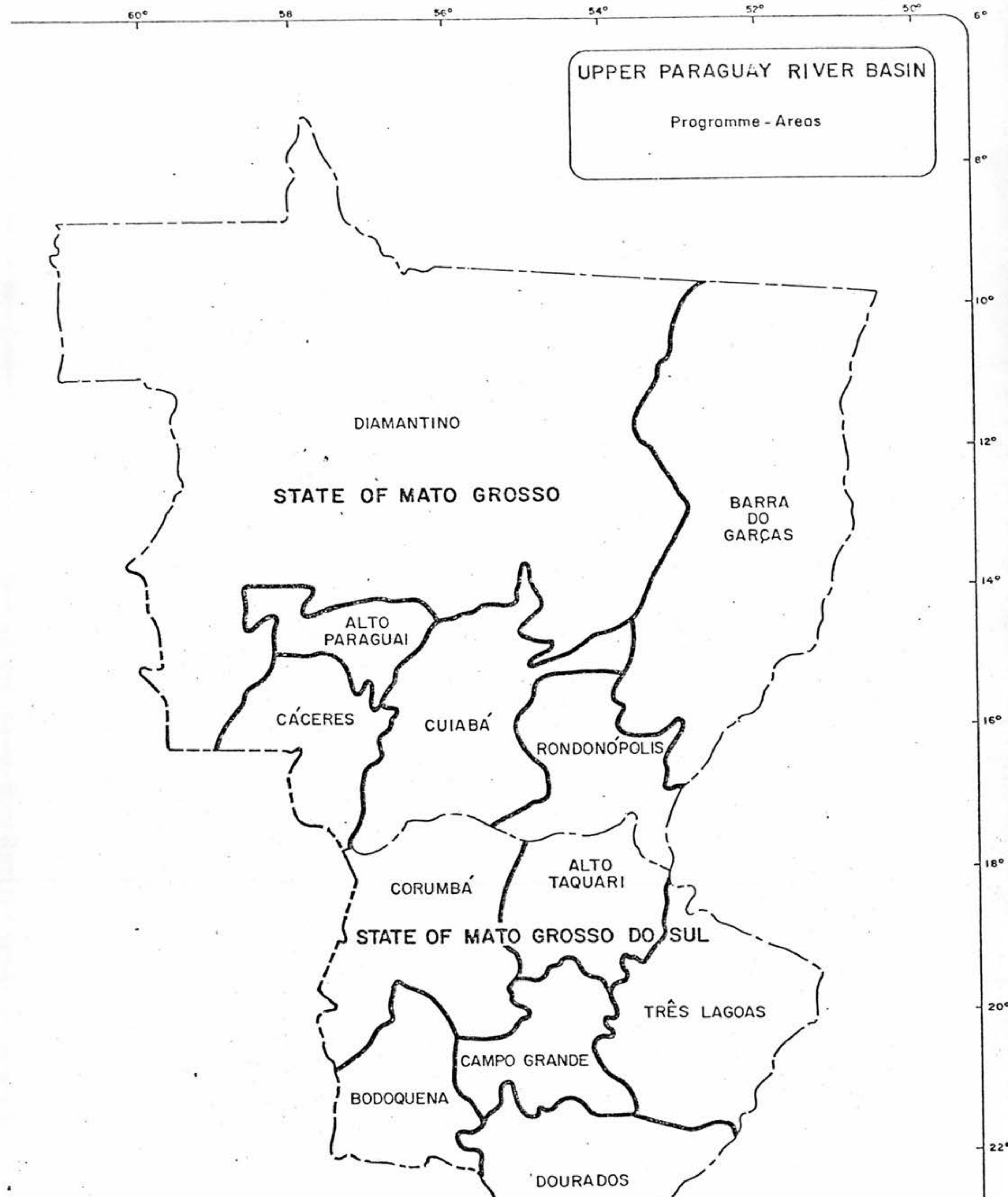
A brief characterization of the recent process of regional development and potentially limiting factors are presented in the following pages.

3.1.1. FACTORS EXPLAINING RECENT REGIONAL DEVELOPMENT

From an economic point of view the basin is to be regarded as an area recently incorporated into the Brazilian economic space which has exhibited great dynamism over the last decade. The high rates of economic growth are explained by the great flows of capital and population coming from the most developed states of Brazil, attracted by the exploitation of natural resources and also by government incentives.

In fact, the existence of a vast endowment of land for agriculture and cattle-raising as well as mineral deposits in the proximities of the most populated states of the country, makes the basin a natural

Map 3.3



Source: EDIBAP

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

PROGRAMME AREAS DEFINED FOR PLANNING PURPOSES

STATE	PROGRAMME AREAS	POPULATION (1980)	EXTENSION (KM^2)	MAIN URBAN CENTER
MATO GROSSO	ALTO PARAGUAI	91,974	28,421	Tangará da Serra
	CACERES	161,878	40,376	Cáceres
	CUIABA	477,171	76,603	Cuiabá
	RONDONOPOLIS	200,409	49,863	Rondonópolis
	BARRA DO GARCAS (*)	122,670	183,750	Barra do Garças
	DIAMANTINO (*)	94,208	503,649	Sinop.
MATO GROSSO DO SUL	ALTO TAQUARI	85,933	47,104	Coxim
	CAMPO GRANDE	352,680	37,555	Campo Grande
	BODOQUENA	94,862	44,113	Jardim
	CORUMBA	124,138	79,598	Corumbá
	TRES LAGOAS (*)	163,673	74,900	Tres Lagoas
	DOURADCS (*)	540,309	69,100	Dourados

SOURCES: FIBGE, 1980; EDIBAP, 1979
(*) Programme areas not forming part of the Upper Paraguay River Basin

area for colonization. Consequently, its recent development is to be seen as externally induced. A satisfactory explanation of this process requires a consideration of various factors, the most relevant being:

- the increase in the national demand for agricultural land, the location of the basin and its endowment of natural resources;
- the land tenure system, and
- public sector action.

Let us examine these in turn:

i) National demand for agricultural land, the location and productive potential of the basin

National demand for new agricultural land derives from the difference between the rates of growth of the demand for food and that of land productivity. Historically land productivity in Brazil has grown at a rate of 1% per year, while demand for food has registered annual rates of not less than 3.5%. Thus, the need to meet the requirements of internal demand alone has generated an expansion of the agricultural frontier at a rate greater than 2.5% per year over the last decade. This has meant the incorporation of more than 800,000 hectares per year in addition to the land required by the expansion of cattle related activities.

This increasing demand for agricultural land together with that derived from primary exports (which have also been expanding), led to the exhaustion of the productive frontier in the traditional agricultural regions of the South-East and South. As a result, agricultural expansion reached Mato Grosso do Sul, at the end of the sixties, and Mato Grosso shortly afterwards.

This process was encouraged by the abundance of land and also by the proximity of the study area to the States of Paraná and Sao Paulo, both of which already practised highly dynamic agriculture and intensive cattle raising. This proximity also guarantees good market conditions for regional products in major centres of the country.

Two additional factors are of importance for explaining the development of the study area. On the one hand, its location in relation to Paraguay and Bolivia gives the area special geopolitical relevance and also creates good conditions for international trade. This latter factor is a very important bargaining tool in the hands of state governments since Brazil suffers from a chronic deficit in its balance of payments and desperately needs to increase exports. On the other hand, its position as an intermediate region between the industrialized states of the South and South-East and the Amazon region makes the study area an important bridgehead for the future process of incorporating the Amazon region into the mainstream of Brazilian life. This constitutes one of the country's most important geopolitical objectives.

ii) Land tenure system

Ownership and land tenure are important elements for explaining the productive structure of agriculture, the utilization of geographic space, labour capital relations and also the distribution of income in rural areas.

The study area was first colonized by peasants migrating from the south who were primarily interested in clearing small pieces of land in the virgin forest for cultivating subsistence crops (mainly rice).

This process is highly labour intensive. Normally however, intensive cropping of this nature is not supported by the use of fertilizers and after a few years land productivity falls. This creates serious difficulties for families engaged in this type of subsistence agriculture, who are then often compelled to sell their small properties and move on, only to start the process over again in a new location. The now "cleared" land left behind is incorporated into bigger farms where it is utilized for large scale agriculture with intensive technologies (and consequently low labour requirements) or for extensive cattle raising.

Thus, the basin is characterised by a high degree of concentration of land ownership. In 1975, 78.7% of farmers owned only 2.6% of the total area covered by the census, while 6.8% owned 86.2% of the total land. Gini's coefficient of concentration rose from 0.88 in 1959 to 0.94 in 1975 (EDIBAP, 1979).

This process has had significant implications for investment and development in this area. On small farms agriculture is the most important activity while extensive cattle raising prevails on the bigger ones. A considerable underutilization of land can be seen on farms of all sizes. On the smaller ones this is mainly due to a lack of machinery (low capital/labour ratio) and to the difficulty of access to bank credit and official channels of commercialisation. Underutilization of land on the bigger farms generally derives from the speculative character of productive investments, which leads to a preference for extensive cattle raising. This activity requires low operating costs and a small labour force, both highly functional conditions for absentee landlords.

The expansion of the agricultural frontier has behaved like a great wave moving from the South to the North-West (in the direction of the Amazon region), the advance of which is represented by thousands of migrating subsistence farmers who clear the land and then transfer it to big landowners, thereby consolidating the incorporation of land into the market economy. Since investment in infrastructure follows the "wave" but with a certain time lag, its effect on land value benefits the big farmers with scarcely any benefits going to the people who really open the frontier.

iii) Public sector action

The urgency felt by the country to increase food production and to devote new areas to the production of alcohol from sugar cane (the latter is a national commitment arising from the great impact of the current oil prices on the Brazilian economy) has inspired a policy of public incentives for the expansion of the agricultural frontier. These incentives include investment in infrastructure, special development programmes and above all a large number of highly subsidized loans for agriculture, cattle raising and related industry.

Thus, Federal and State Government behaviour, expressed in the level and structure of public investment and current expenditure, is to be regarded as a decisive element for explaining regional development in the study area.

Public investment has grown progressively over the last 15 years. It has been concentrated in physical and social infrastructure projects (transport, communications, energy, education and health). Important resources have also been allocated to agricultural experimentation and extension as well as to the improvement of the commercialization of agricultural products and inputs.

The most impressive impact of public action can be seen in the road network. In 1965 paved roads in the basin did not amount to 100 km, all of which were concentrated around Campo Grande, the rest being of such a low quality that they could only be used for a few months of the year.

By 1978, however, there were over 1500 km of paved roads and the remainder of the network amounted to more than 8000 km of other roads of reasonable quality.

Although the contribution of this type of public investment to the gross regional product is relatively small, it has considerable multiplier effects, creating good conditions for attracting private investment into the region. This incentive combines with the attractions of the highly subsidized long-term loans for investment, and rural electrification which, besides their direct effects, all increase land value and, thus, make possible the generation of great profits through land speculation.

These three development-inducing elements together with other particular regional factors have accelerated the incorporation of new lands into productive use, giving rise to a sizeable inflow of human and financial resources from other regions. It is necessary to point out that land speculation constitutes, perhaps, the central element for attracting private initiative and capital into the region.

3.1.2 FACTORS LIMITING FUTURE REGIONAL DEVELOPMENT

Although the type of development described has been particularly efficient for promoting economic growth, it has nevertheless important deficiencies which may inhibit its future dynamism.

In the first place, the process leads to a high concentration of land ownership and consequently income. Hence big farms, exploited with capital intensive technologies, co-exist with large sectors of the regional population engaged in subsistence agriculture on very small farms. Obviously, this situation creates social problems that may become acute in the near future, especially in view of the process of political liberalization taking place in the country.

Secondly, current land use practices are frequently in conflict with the maintenance of an ecological equilibrium. Since this conflict occurs throughout the area regardless of the size of farms it is possible to foresee a significant fall in average land productivity in the medium term. If no corrective measures are taken soon, regional growth potential will be severely curtailed and the recovery of fertility may necessitate substantial investment.

Thirdly, the speculative character of most of the agricultural and cattle raising investment suggests that landlords are more interested in the increase in the value of their lands resulting from public investment (roads, electrification, etc) and in the benefits of using subsidized loans than in increasing land productivity. This is reflected in the great dependence of any increase in cultivated area upon agricultural loans and also in the fact that a large proportion of the land belongs to people resident in other states(*). Obviously this is one great weakness of the regional economy, since these facts demonstrate that it is entirely dependent on external resources.

Fourthly, rural development has been an extensive and to a certain extent explosive process which, in spite of a considerable effort on the part of the government, has made it difficult to provide the population with basic services (health, education, water supply, justice, etc) and has also inhibited the consolidation of an integrated system of urban settlements. This contributes to an increased social imbalance between rural and urban areas and stimulates the spontaneous growth of the main urban centres (Campo Grande and Cuiabá).

Finally, the exogenously induced character of regional growth has affected the behaviour of local industry, especially that related to agriculture, which constitutes a strategic sector of the regional economy.

In fact, the meat industry, rice processing plants and other important industries are subsidiaries of national firms located in the most developed states. As a result, the level of activity of these industries in the region is determined mainly by the objective of maximizing the overall profits of such firms rather than by the promotion of regional primary production or the expansion of their activities in the study area. In specific terms this means that they act as a monop olies, their primary objective being to ensure low-cost inputs for their main factories (usually located in the State of

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(*) Recent studies carried out by SUDECO (SUDECO, 1978) demonstrate that in the period 1970-76 the value of (highly subsidized) loans for agriculture granted by the Banco do Brasil in the States of Mato Grosso and Mato Grosso do Sul rose progressively from 22.5% of the total agricultural product to 94%. With regard to land ownership Di Sabbato (DI SABBATO, 1976) holds that in the middle seventies 40% of the area of both states (50 million hectares) was owned by people who were residents of the State of Sao Paulo.

Sao Paulo) so that the processing of such inputs in Mato Grosso, becomes a matter of secondary importance.

Taken together, all these considerations enable us to conclude that although the region has exhibited impressive rates of economic growth in recent years, it is very unlikely that these rates can be maintained in the future, especially when one bears in mind that the crisis now facing the Brazilian economy (120% inflation, US$3,5 billions deficit in the balance of payments in 1980) has compelled the government to adopt drastic measures for reducing public expenditure and investment programmes and to a severe cutback on bank credit. From another point of view it is possible to foresee that the process of political liberalization will bring strong pressure to bear on the government to reduce social inequality. Since the elements that induced regional economic growth simultaneously increased the concentration of land and income, any attempt to modify such factors in order to reduce social inequality will inevitably bring about a slackening of the expansionary tendencies in the economy, at least in the short run.

3.2 PURPOSES AND THEORETICAL FOUNDATIONS OF THE MODEL

In order to formulate a development plan for the above region, the Brazilian Government, through its Ministry of Interior, requested the technical assistance of the Organization of American States and the financial aid of the United Nations Development Programme giving rise to the Integrated Study of the Upper Paraguay River Basin (EDIBAP).

This joint project established that the study must lead to the formulation of a comprehensive plan for the utilization of the natural resources of the region. Such a plan should emphasize the following aspects: development of agriculture and cattle-raising, manufacturing of regional materials, regulation of the main water courses, transportation, expansion of the supply of energy, ecology, human resources and urban development (EDIBAP, 1979; p.10).

The study was divided into two phases. The first was devoted to basic studies of natural resources, socio-economic diagnosis and preliminary identification of investment projects. The second phase included sectorial programming, detailed studies of projects and the formulation of the regional development plan with recommendations for its implementation.

Because of the nature of the studies and a lack of published information, the first phase required a vast amount of field work. This, together with the diverse disciplines involved in such studies, led to the formation of a number of relatively independent technical groups. The outcome of this first phase consisted of detailed studies of hydrography, vegetation, soils, infrastructure and a very complete socio-economic survey that represented a considerable increase in the knowledge of the region.

In spite of these achievements, at the beginning of the second phase it was felt that the whole study lacked integration and that too much effort was being devoted to basic studies of natural resources at the expense of the analysis of specific development proposals. Since at that time it was clear to the technical team that the end product of the study should be a regional development strategy complemented by sectorial policies and specific projects (rather than a rigid and detailed regional plan), a revision of the overall methodology of the study was undertaken.

After reviewing current planning methodologies and the experience of similar regional studies, "the strategy-projects" approach was accepted as a sensible procedural framework for orientating the second phase of the work. This implied the construction of a simulation model of the regional system, the study of policy instruments available at the regional level, greater emphasis on the study of specific investment projects and also the exploration of possible development strategies.

In this context, it was decided that the main purpose of the model was to integrate several partial studies to enable the quantification, by means of simulation techniques, of the probable effects on the regional system that would derive from the implementation of different policies and specific projects.

The model is basically an economic-demographic one of spatial activity change, that emphasizes the role of agriculture and cattle raising as the most dynamic sectors of the regional economy.

For a better understanding of the model a brief review of its theoretical background is presented in the following sub-sections. This involves both a discussion of some characteristics of the model imposed by the procedural framework used in the overall study and an overview of the theory of regional development that constitutes its substantive framework.

3.2.1 THE PROCEDURAL FRAMEWORK

The institutional context in which EDIBAP operated is one of the elements that most decisively determined the overall structure of the model since it guided the selection of the methodological approach to the whole study. In fact, to the extent that EDIBAP was created as a project of technical assistance to the Brazilian Government it had a temporarily limited existence and it did not form part of the permanent Brazilian planning system.

This means that EDIBAP had to deal with a complex and highly dynamic regional system without direct involvement with day to day decision making. It was not to participate in monitoring the implementation of development proposals. In these circumstances the most important contribution of the technical assistance project was to transmit to regional authorities and permanent planning agencies a philosophy of regional development and a procedural framework for planning activities involving mechanisms for monitoring the implementation and reformulation of development proposals.

In the context of the adopted procedural framework (the "strategy-projects" approach) the regional development plan proposed by EDIBAP is to be seen as a minimum set of measures and investment projects for generating the initial phase of a long term process of regional development. These should be complemented by new actions as soon as the initial measures and investment projects achieve their objectives or fail to generate the expected effects.

The moment at which complementary actions are to be implemented, as well as their intensity and orientation, must be defined in accordance with the outcome of the continuous scanning of the regional system to be performed by permanent planning agencies. The model is expected to play an important role in such assessments by enabling rapid comparisons between actual and expected behaviour. It must also contribute to the design of new interventions in the system by helping the study of probable effects that may derive from the implementation of alternative courses of action.

In order to fulfil such functions the model must meet at least four basic conditions. First, it must have "requisite variety" to match the complexity of the regional system. The model must be able to manipulate a large number of variables linked with diverse types of relationships and also disaggregated in various spatial units. In fact, a region as large as the Upper Paraguay River Basin presents a complex demographic pattern with significant spatial variations in the factors affecting population growth. For example, life expectancy is significantly less in remote rural areas than in the main cities; migration causes increases in the population living in zones of the agricultural frontier and decreases in areas where agriculture is increasing its level of mechanization. The regional economy comprises several sectors of activity, each with a different spatial pattern and where growth is the outcome of different types of stimuli. Thus, to represent a region of such complexity accurately, a few aggregate variables are not enough; rather it is necessary to define specific sectors and subregions with their own set of variables, parameters and equations.

Second, the model must properly reproduce the main feedback relationships that are observed in the regional system. A typical example of feedback in regional systems is the interdependence between population growth and the growth of employment (frequently measured in terms of unemployment rates). An increase in job opportunities in a given area is an attraction for people living in other areas. Such migration leads to abnormal population growth which (after a period of time) will generate an additional demand for new jobs. If the area fails to meet such new levels of employment, unemployment rates will rise and feedback will induce emigration to other areas. In the event that job supply satisfies the greater demand feedback will tend to reinforce inmigration, exaggerating the problem. The presence of such feedback relationships enables the model to be used as part of a cybernetic system of planning.

Third, the model must provide an explicit treatment of the main policy instruments to be employed for promoting regional development. Thus special equations are incorporated in the model to reproduce the effects of any alteration of the variables controlled by regional or national authorities, such as public expenditure, public works and loans.

Fourth, the model must be dynamic. It must be able to reproduce the temporal evolution of the main variables.

In order to satisfy all these conditions the model inevitably contains a large number of variables, time lags, non linearities, constraints affecting some variables, and special procedures for spatial disaggregation.

In summary, the characteristics of the procedural framework adopted led to the formulation of a relatively complex economic-demographic model of spatial activity change to be used for policy simulation purposes. It is necessary to bear in mind that the model was conceived as a part of a general methodology for regional planning activities. Although it was utilized a few times during the study, it is expected that its major use and consequently improvements and reformulations will be performed by permanent agencies that deal with the region.

3.2.2 THE SUBSTANTIVE FRAMEWORK

In designing a model for a regional economy it is necessary to bear in mind that regional growth theories deal with economic systems that are very "open", in contrast with national income theory, which deals with relatively "closed" economies.

National economic growth models, with varied emphases, make investment the central element, and obviously actual growth will depend on the ability of the national system to meet the requirements of investment with internal or external resources.

At the regional level the situation is different, mainly because of the greater relative mobility of production factors and of goods and services. Thus a small region is faced with what is essentially a perfectly elastic demand for the most of its products, with the result that it can sell all it produces as long as it is able to produce at competitive prices.

Due to the interregional mobility of productive capital, medium and long-run regional potential output is not limited by the current stock of production factors and their rate of change, but by its capacity to attract those factors from other regions.

Thus, regions vie with one another to attract new productive investment and skilled labour, their "attraction elements" being the nature and quality of the natural resources with which they are endowed, infrastructural facilities and other particular conditions which increase the profit expectations of private entrepreneurs.

These broad considerations constitute a general framework for selecting a theory of regional development to be adopted as the basic structure of the economic submodel.

As later explained in section 3.3 our model is actually composed of three submodels: demographic and employment, economic, and environmental and physical. Of these, the second is dominant in that it provides a theoretical background which embraces the other two submodels (see Fig. 3.1). The following pages explain how the study derived the theoretical background of the economic submodel.

From the theories of regional development briefly reviewed in Chapter 1, Siebert's contribution (SIEBERT, 1969) was adopted as the theoretical framework of the economic submodel, since it is one of the most comprehensive attempts to formalize a regional development theory.

However, a lack of reliable statistical data and the general orientation of EDIBAP resulting from the conditions of the programme of technical assistance that gave rise to this study, impose serious limitations on this theoretical conception of the economic submodel. Thus, the theory actually utilized is to be regarded as an "hybrid" formulation derived from Siebert's original work.

For a better understanding of the theoretical background, a brief summary of the main features of Siebert's contribution is presented below. The following pages also explain the assumptions made and the modifications performed on the original formulation for matching the characteristics of the study area, policy orientations and the availability of information.

Siebert distinguishes two separate groups of elements that explain the increase in regional output (internal and external determinants). The first group includes net internal investment, increase in labour and technological improvements as the elements affecting the supply side of a regional economy, and consumption and demand for investment working on the demand side. The external determinants of regional economic growth are interregional trade (affecting aggregate demand), interregional movements of production factors, and technology (operating through the supply side). Siebert postulates that in regional economies, in contrast with national ones, it is not true that the optimum rate of growth is that which equalizes the rate of growth of aggregate demand with that of aggregate supply. This is because monetary equilibrium is a goal of national policies, not of regional ones. It follows that, equilibrium not being the main concern at the regional level, the real rate of economic growth for a particular region will be equal to that rate of growth of aggregate demand or supply which presents the lowest value (SIEBERT, 1969; p.119).

Let us now have a quick look at the main determinants of both sides of a regional economy, following a version of Siebert's model enlarged by introducing the public sector (for greater detail see ORDONEZ, 1975).

The rate of growth of aggregate demand depends on the behaviour of interregional flows of financial resources (demand for investment), interregional trade, the behaviour of the government, and on marginal propensities to save and invest.

In mathematical terms this can be expressed as follows:

$$\frac{\Delta Y_D}{Y_D} = \frac{1}{s+g+\lambda m_1 - b_1(1-\alpha_1)} * \left[\frac{\Delta Y^{II}(\alpha 2\ b2 - \lambda m2) + \Delta G}{Y_D} \right]$$

where

YD = Aggregate Demand of a particular region
Y^{11} = Aggregate Demand of the rest of the country
G = Government expenditure in the region (current and capital expenses)
s = regional marginal propensity to save
g = regional marginal tax propensity
m_1 = regional marginal propensity to import
m_2 = marginal propensity of the rest of the country to import from the region under consideration
λ = coefficient indicating obstacles to interregional trade
= 1, means that no spatial friction exists
= 0, means that interchange costs are so high that no trade can take place
b_1 = regional marginal propensity to invest
b_2 = marginal propensity to invest in the rest of the country
α_1 = coefficient indicating the proportion of regional induced investment that is attracted by the rest of the country
α_2 = coefficient indicating the proportion of induced investment in the rest of the country flowing into the region
Δ = denotes marginal increments.

The expression in brackets represents the proportion of the increase in income generated in the rest of the country and of the increment of public expenditure that flows into the region. The fraction, in its turn, is a modified version of Keynes' multiplier.

For explaining the rate of growth of aggregate supply it is assumed that the production function of the regional economy behaves like a "Cobb Douglas" function (*).

On the assumption of constant technology, the rate of growth of aggregate supply at the regional level depends on increases in the availability of labour and in capital assets. In algebraic terms this becomes:

$$\frac{\Delta Ys}{Ys} = C * \left[(1-E_1) \frac{\Delta K}{K} + E_2 \frac{\Delta K^{\Pi}}{K} \right] + (1-C) * \left[\frac{\Delta P + \delta \ (P+\Delta P) + \delta_2 \ (P^{\Pi}+\Delta P^{\Pi})}{P} \right]$$

Y_s = regional aggregate supply
k = regional stock of capital
k^{Π} = stock of capital in the rest of the country
P = regional population
P^{Π} = population of the rest of the country
E_1 = coefficient indicating proportion of capital generated in the region that flows to the rest of the country
E_2 = idem, but flowing in the opposite direction
δ_1 = rate of emigration
δ_2 = rate of immigration

(*) This means that in the simplest case (constant returns to scale) aggregate supply becomes:

$$Y_s = h*K^c*L^{(1-c)}$$

where
Y_s = regional aggregate supply
h = level of technological knowledge
K = stock of capital
L = labour force
c = production elasticity of capital
$1-c$ = production elasticity of labour
Consequently the rate of growth of aggregate supply can be expressed as follows:

$$\frac{\Delta Ys}{Ys} = \frac{\Delta h}{h} + C * \frac{\Delta K}{K} + (1-C) \frac{\Delta L}{L}$$

As mentioned above, since the achievement of an equilibrium rate of growth has no sense on a regional scale, the real growth rate will coincide with that rate of growth of aggregate demand or aggregate supply which presents the lower value. This condition can be expressed as:

$$\frac{\Delta Y}{Y} = \min \left[\frac{\Delta Y_D}{Y_D}, \frac{\Delta Ys}{Ys} \right]$$

Such a growth rate does not necessarily imply full employment, although it can be expected that mobility of labour will allow surplus workers to migrate to areas with a labour shortage.

There is another aspect that requires some comment. In an open region, the effective rate of growth may be affected not only by the factors already discussed, but also by the behaviour of interregional terms of trade.

If export prices rise faster than those of imports, the region will be able to increase imports without having to reduce other items of expenditure. As regional income is a measure of the set of commodities available to a region, improvements in the terms of trade must be regarded as raising regional income. Consequently, any deterioration in the terms of trade reduces the level of regional income.

Thus, the effective rate of growth of a regional economy becomes:

$$\frac{\Delta Y}{Y} = \min \left[\frac{\Delta Y_D}{Y_D}, \frac{\Delta Ys}{Ys} \right] + \frac{\Omega}{Y}$$

Where $\frac{\Omega}{Y}$ represents the positive or negative variation in the overall rate of growth due to variation in the terms of trade.

Thus, this approach explains regional economic growth as the result of the interaction of several factors. Economic growth at the national level, just like the growth of a national economy, is greatly influenced by variations in:

i) availability of production factors
ii) technology
iii) government behaviour
iv) foreign trade behaviour, and
v) saving and investment propensities

Due to the greater "openness" of regions, some variables achieve a strategic importance affecting the regional growth rate and, in spite of being included in some of the variables already mentioned, it is necessary to list them as separate items.

As Czamanski points out, regional growth is partially explained by the improvement of internal conditions, but it has traditionally been more dependent on the capacity of the region to attract dynamic elements from the rest of the country. As such, both the volume of production factors susceptible to interregional transfers and interregional price differentials of commodities and their relative degree of mobility, become key elements in explaining the rate of growth of a particular region.

Thus, in the case of regional growth, our list of determinants has to be enlarged to include:

vi) national growth rates
vii) interregional price differentials of commodities and production factors, and
viii) degree of mobility of commodities and factors of production.

Consequently, any economic growth policy should be oriented to the regulation of some (or all) of these elements by means of specific policy instruments. In order to adapt this theoretical formulation to the particularities of the integrated study for the development of the Upper Paraguay River Basin the following procedure was adopted.

Firstly, policy instruments available at the regional and national levels were defined and adopted as the basic explanatory variables of the economic submodel. Secondly, by means of fragmentary historical data, the behaviour exhibited by aggregate supply and demand during the last twenty years was analysed in order to pinpoint the limiting factor of regional development. Thirdly, the role allocated to the region by Brazilian development policies was used to select the fundamental variables of the model from those that operate through the limiting factor of regional development just defined. Finally, this set of variables was further assessed in terms of the accuracy of quantification that available statistical information would allow.

Let us consider the conclusions obtained by these means.

To analyse the policy instruments utilized in Brazil for promoting regional development, the typology proposed by Siebert (SIEBERT, 1969, p.193) was adopted. This author classifies instruments of regional growth policies according to three different criteria:
(1) the determinants of regional growth which they influence,
(2) the size of the area which they are intended to affect, and
(3) the intensity of interference with the market economy.

Of these criteria the first was the most appropriate one, in our case. Five types of policy instrument were distinguished. Let us examine them:

a) Labour-supply measures. This category includes all policy variables which influence regional labour-supply both in quantitative and qualitative terms.

   In the study area the public sector only influences labour supply through the traditional programmes of health, education and professional training with a view to improving the quality of labour, and through colonization programmes acting on the quantitative side.

b) Capital-supply measures. Traditionally regional development in Brazil has been highly dependent on this type of measure. In fact, public investment in infrastructure, federal transfers to specific industries (e.g. the alcohol industry for substituting petroleum), tax reductions for investment in the region, subsidized credits for investment and financial capital, etc. must be considered in this category.

c) Instruments for technical progress. The most important instruments for improving technology in the region are the research programmes in agriculture and cattle raising carried out by EMBRAPA (Brazilian Agricultural Research Corporation) and the programme of technical assistance to farmers implemented by EMBRATER (Brazilian Institute for Technical Assistance). Both are linked to the Ministry of Agriculture and operate in the region in conjunction with their state counterparts.

d) Demand-influencing instruments. Under this heading are summarized all measures that increase internal or external demand for regional products. In the study area the amount of public expenditure is a very important determinant of internal demand. In addition to this quite obvious instrument the purchasing power for agricultural and cattle products monitored by CFP (commission for production loans) and the officially controlled commercialization systems for coffee, sugar and alcohol, should be mentioned.

e) Location and mobility instruments. This category includes the instruments classified in the first three groups but defines particular criteria for their use. The most important elements are the location decisions for public works (especially the design of the road network) and services (health, education, storage, etc.), subsidies to attract industries, settlement programmes, etc.

Thus, so far as the model is concerned, these policy instruments were selected as the basic explanatory variables, since the function of EDIBAP is to provide the Federal and State Governments with guidance and advice on the most appropriate use of these instruments.

Once the most important policy instruments to be manipulated through the model had been defined, attention was focused on the historic behaviour of aggregate supply and demand in order to identify which was the limiting factor of regional growth. From aggregate demand determinants, public expenditure, exports, and interregional transfers of financial resources were studied; the remaining factors were assumed to behave in a similar fashion to that of their national counterparts (saving, investment and tax propensities and coefficients referred to mobility of financial capital and commodities).

Public expenditure in the region is channelled in three different ways, namely through Federal Government agencies and special programmes, State Governments and municipalities. State Government expenditure was selected as representative of the whole public expenditure since a great proportion of federal resources are transferred to agencies of the State Government to be applied in specific programmes and appear in consolidated balances of the State Government. Municipalities represent a small part of total expenditure and the most significant part of their resources consists of transfers from the State Government.

Table 3.2 shows the evolution of State Governments' expenditure from 1965 to 1978. Total expenditure grew at a rate of 23.7% during that period and at a rate of 23.8% between 1970 and 1978. Since the average rate of growth of regional product between 1959 and 1980 was 8.7% per year, it can be concluded that, as far as public expenditure is concerned, there have been no limitations to a greater rate of growth.

TABLE 3.2

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
EVOLUTION OF STATE GOVERNMENT EXPENDITURE (1965-1978)

(MILLION CRUZEIROS-CURRENCY APRIL 1980)

YEAR	CURRENT EXPENDITURE	CAPITAL EXPENDITURE	TOTAL
1965	605	279	884
1966	792	147	939
1967	1,189	439	1,628
1968	1,258	595	1,853
1969	1,301	1,159	2,460
1970	1,552	984	2,536
1971	1,880	673	2,553
1972	2,300	2,162	4,462
1973	3,027	2,332	5,359
1974	3,739	3,688	7,427
1975	5,091	3,831	8,922
1976	6,197	5,246	11,443
1977	7,269	3,414	10,683
1978	8,458	5,575	14,033

SOURCE: ANUARIOS ESTATISTICOS DO BRASIL (STATISTICAL YEARBOOKS OF BRAZIL)

Although the region presents a negative balance in its interregional trade, exports have been highly dynamic. To assess the future contribution to the growth of aggregate regional demand, the expected growth rates of demand for regional products in the national market need to be analyzed. The region specializes in agricultural and cattle products and the country as a whole is a net importer of such goods. It follows that there are few restrictions on the expansion of regional exports and they cannot be regarded as limiting further growth of aggregate demand.

In the case of interregional transfers of financial capital the situation is quite complex. Here a lack of information makes it difficult to reach a clear conclusion. On the one hand a great proportion of land belongs to people resident in other states. Since this transfer of ownership occurred on a massive scale during the seventies there is a basis for estimating an important inflow of capital for the purpose of land acquisition.

Similar conclusions can be drawn from studying the behaviour of bank credits, especially those highly subsidized loans for agriculture and cattle raising (see Table 3.3).

On the other hand some studies suggest that a large proportion of the credit granted for agriculture and cattle raising is diverted to more profitable investments in other regions (HOLANDA, 1979; EDIBAP, 1980). This assumption is based on the fact that while rural credit represented 22.5% of rural output in 1970, this proportion grew to 94.0% in 1976. Since other significant investments implemented during that period have identifiable sources of resources, the hypothesis of those redundant resources directed to rural activities being transferred to other states cannot be disregarded. Since a part of the investment capacity generated within the region may move in the same direction (industries that are subsidiaries of firms located in other states, etc.), it was assumed that interregional flows of financial capital play a neutral role as a determinant of aggregate demand growth.

These elements lead to the conclusion that aggregate demand presented a higher rate of growth than regional product during the last two decades and consequently a development plan for the region

TABLE 3.3

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
LOANS GRANTED FOR AGRICULTURE AND CATTLE RAISING (1969-1979)
(MILLION CRUZEIROS - CURRENCY OF APRIL 1980)

YEAR	AGRICULTURE				CATTLE RAISING				AGRICULTURE AND CATTLE RAISING			
	NORMAL COSTS	INVESTMENT	COMMERCIALIZATION	TOTAL	NORMAL COSTS	INVESTMENT	COMMERCIALIZATION	TOTAL	NORMAL COSTS	INVESTMENTS	COMMERCIALIZATION	TOTAL
1969	267.6	65.5	76.1	409.2	389.5	1,299.5	176.4	1,865.4	657.1	1,365.1	252.4	2,274.6
1970	331.6	79.1	115.4	526.1	271.1	1,604.9	657.1	2,533.1	602.7	1,684.0	772.5	3,059.2
1971	444.9	176.4	50.4	671.7	446.5	1,796.4	976.5	3,219.4	891.4	1,972.8	1,026.9	3,891.1
1972	787.6	993.2	176.9	1,957.7	544.7	3,058.7	1,383.2	4,986.6	1,332.3	4,051.8	1,560.1	6,944.2
1973	1,161.5	789.1	322.0	2,272.6	621.8	5,916.8	1,150.4	7,689.0	1,783.3	6,705.9	1,472.4	9,961.6
1974	2,359.2	1,041.1	377.4	3,777.7	1,568.6	5,325.7	1,952.1	8,846.4	3,927.9	6,366.8	2,329.5	12,624.2
1975	6,572.9	4,078.1	910.0	11,561.0	4,803.7	5,836.7	2,309.8	12,950.2	11,376.6	9,914.7	3,219.9	24,511.2
1976	12,447.3	8,963.4	2,745.7	24,156.5	1,949.1	9,384.6	2,968,0	14,301.7	14,396.4	18,348.0	5,713.7	38,458.1
1977	17,818.4	7,699.1	2,818.8	28,336.3	2,080.1	5,602.9	2,246.9	9,929.9	19,898.5	13,302.0	5,065.7	38,266.2
1978	26,211.9	12,802.6	2,454.0	41,468.4	2,418.2	4,474.1	3,287.9	10,180.2	28,630.1	17,276.7	5,741.9	51,648.7
1979	17,280.4	7,081.8	2,152.2	26,514.2	2,661.1	7,978.7	3,872.5	14,512.3	19,941.3	15,060.6	6,024.6	41,026.5

SOURCE: BANCO CENTRAL DO BRASIL (CENTRAL BANK OF BRAZIL) must emphasize the expansion of aggregate supply. The next step consisted of studying the orientation of current policies for regional development and the specific purposes that the EDIBAP study was expected to serve.

From the Third National Development Plan and current regional development policies the following functions for the Upper Paraguay River Basin can be drawn:

a) To provide the national market with significant quantities of food, raw materials, minerals and timber, and also to export products derived from agriculture and cattle raising.

b) To act as a receiver area of interregional migration and as an area of expansion of the national agricultural frontier.

c) To constitute the basis for the process of incorporating the Amazon Region into the Brazilian socio-economic system.

Thus, the regional development plan under formulation (and consequently the simulation model) is expected to generate guidelines for increasing food production, orientating the expansion of the agricultural frontier and for consolidating an efficient and dynamic regional economy. In this way available policy instruments, the objectives defined by Brazilian authorities, historic behaviour of the regional economy and the quality of information, necessarily resulted in an orientation for the economic submodel that emphasized the expansion of aggregate supply.

3.3 AN OVERVIEW OF THE MODEL

Having described the main features of the development of the Upper Paraguay River Basin during the last decade and having reviewed the theoretical foundations of the simulation model, this section now provides a synoptic view of the structure of the model and later outlines some technical aspects of its estimation and validation.

This section is divided into three main parts. The first of these defines the problem the model is designed to solve. The second contains a description of the model's structure, whilst the third discusses, from a theoretical point of view, its estimation and validation. The main features of the computer programme utilized for simulating the model are presented in Appendix 1.

3.3.1 PROBLEM FORMULATION

The problem EDIBAP faced was the formulation of development strategies for a particular region. As such, the model's subject matter is primarily defined by the set of variables which determine the feasible strategic options for the orientation of the region's comprehensive development.

Due to the complexity of the regional system and because of the scarcity of reliable statistical data to estimate behavioural equations, policy variables were reduced to:

a) Credits for agriculture and cattle-raising
b) Agricultural prices policy
c) Public current expenditure
d) Public incentives for export industries (Tax exemption policy)
e) Public investment in roads and housing, and
f) Public investment in social sectors (health and education).

The model, therefore, was designed to simulate the effects that one or more governmental policies or strategies, relating to the above variables, might have on a) regional income; b) employment; and c) regional savings gap.

Policies and strategies are represented by a set of values (of policy variables) which are fed into the model which is run for a given time period. Each simulation produces a time series of values for each endogenous variable. Several runs must be performed in order to explore a reasonable number of possible decision-making options.

3.3.2 STRUCTURE OF THE MODEL

Perhaps the most important characteristic of the model lies in the fact that it is not a tool for maximizing production (or any other variable), rather it is a vehicle for performing experiments to determine the cause and effect relationships between policy options and response variables such as regional product, income per capita, unemployment rates, etc.

Although the model does not contain any built-in optimization function, repeated simulations allow one to develop sets of policies in which employment objectives, goals of economic growth, ecological constraints and the area's investment capacity are all compatible. In this way the model is designed to help policymakers to draw together the various, previously disparate elements, into a harmonious regional strategy.

By combining aspects that are normally treated separately, the model enables one to test the degree of exogenous alteration that the variables regulating regional development can tolerate, while still producing feasible and internally consistent development strategies.

In order to accomplish this, the model integrates some widely recognized submodels. For further clarity, and in addition to the background to the economic submodel provided earlier, each of the submodels is now briefly described below; the explanation of how they are interrelated is left until the end. A synoptic view of the model is presented in Fig. 3.1.

i) Demographic and employment submodel

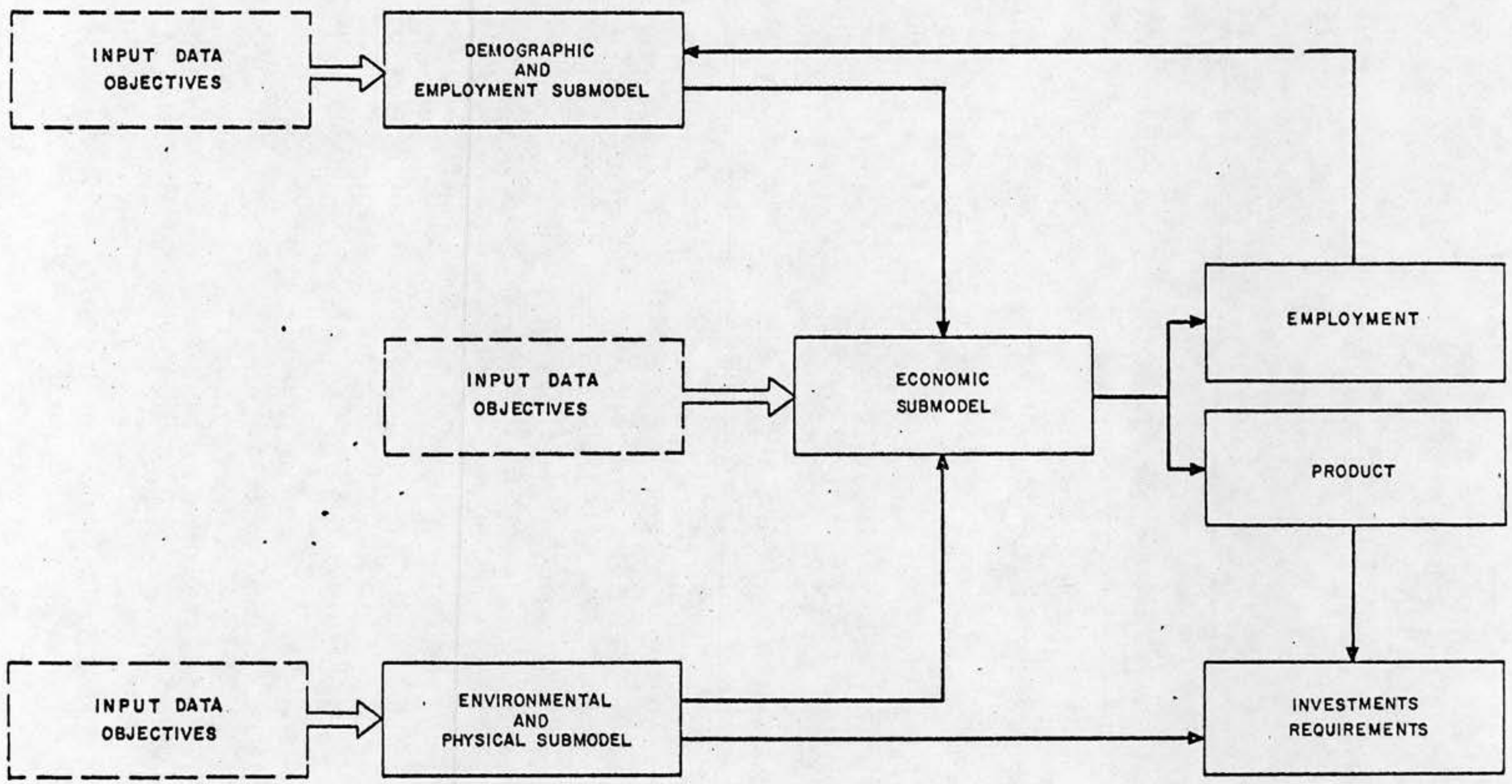
This submodel predicts the volume and composition of regional population, and then derives the availability of human resources. In order to provide an adequate framework for the study of spatial phenomena, all predictions are disaggregated at the subregional level (programme-area).

Demographic projections are made by means of a cohort-survival method. Firstly, the effects of natality, mortality and migration are determined (either exogenously or by means of specific behavioural equations) and then introduced into an accounting structure. This adjusts the base year population of each sex and age cohort by inflows (births and immigration), outflows (deaths and emigrations) and places them into the relevant new cohort during the forecasting period.

The projected population is then disaggregated into urban and rural using a behavioural equation. This is followed by calculation of the urban and rural labour force and the corresponding job requirements. The labour force is derived from applying participation rates to the urban and rural population, disaggregated by sex and age, and the job requirements for these areas are determined by utilizing maximum acceptable unemployment rates which represent the objectives of employment policy. The most important feature of the demographic submodel is the treatment given to net migration. This is estimated through a set of behavioural equations which explain net migration rates as a linear function of total employment growth rates. Such a relationship makes it possible to introduce a feedback relationship into the composite model which explains net migration rates for a given year in terms of the job creation performance of the regional

Figure 3.1

STRUCTURE OF THE MODEL



economy during the previous year.

ii) Economic Submodel

The main function of this submodel is to estimate the sectorial production and labour demand (jobs generation) resulting from the implementation of specific economic policies, such as price policies for agricultural products, monetary measures, modifications on current fiscal policies, etc.

According to the theoretical view of regional economic development presented above, this submodel focuses on variables affecting the supply side of the regional economy on a sectorial basis. It identifies four basic sectors: a) agriculture, b) cattle raising, c) industry, and d) civil construction together with tertiary activities. Consistent with the characteristics of the Upper Paraguay River Basin and with the role defined for this region by Brazilian regional policies, agriculture and cattle raising received priority attention. Let us have a brief look at each of these sectors.

a) Undoubtedly, the most salient features of the agricultural sector of the economic submodel are the behavioural equations which explain the expansion of the agricultural frontier and the evolution of the area devoted to rice and soya (two of the four basic regional crops) and then allow the determination of the production and employment generated.

   The first function explains the increase of the area under cultivation and pasture in terms of the expansion of the road network and the amount of credit granted for agriculture and cattle-raising. Since both independent variables are fully controlled by State and Federal governments (and also constitute traditional policy instruments for promoting regional development), this function permits an endogenous treatment of this important and complex phenomenon. It also determines the amount of land devoted to pasture each year, which is then fed as an input to the cattle-raising sector.

The amount of land devoted to rice and soya, is explained by means of an agricultural supply function that incorporates the concept of "expected normal price". In order to estimate such a behavioural equation from time series data, a special transformation (KOYCK's Transformation) was used which replaces the unknown "expected price" with a combination of lagged values of dependent variables and observed past prices. The introduction of time lags into the equation leads on the one hand to relatively stable projections (because of the high incidence of past observed values of both dependent and independent variables), and on the other hand makes the model iterative.

The area to be devoted each year to crops and pasture is constrained by an ecological limit reflecting the objectives of environmental policy. Such a constraint is exogenous to the agricultural sector and is later defined in the so-called physical and environmental submodel.

After quantifying the area to be devoted to each crop, the model determines physical production, gross value of production and permanent and temporary employment. Production estimates are obtained by applying physical productivity coefficients to the number of hectares allocated to each crop and then multiplying by market prices.

A lack of information prevented an endogenous treatment of physical productivity. However it can be treated as a critical variable and used for special experiments.

On a monthly basis, employment is quantified by means of a set of coefficients representing labour requirements per hectare of each crop and then disaggregated into permanent and temporary jobs. These coefficients are determined exogenously but an equation for combining mechanized and manual technologies for rice and soya crops was introduced into the model.

b) The cattle-raising sector contains a set of cohort-survival relationships for projecting the evolution of the stock of cattle. Natality and mortality rates are determined exogenously. The model only accounts for the extraction of animals for slaughter and for transfers of live cattle between programme areas.

The behavioural equations for explaining extraction rates are similar to the supply function utilized for rice and soya. They express extraction rates for a given year as a linear function of past observed extraction rates, historical market prices of meat and credit granted to this activity. Such functions are estimated for the whole region and it is assumed that they are valid for all programme areas.

Cattle transfers between programme areas are estimated by means of a double logarithmic function in which the independent variable is a cattle/pasture ratio. For determining this ratio for each year of the simulation period the area devoted to pasture in each programme-area is obtained from the agricultural sector.

Once the cattle stock (and its sex and age structure) is established the model derives the gross value of production and employment generated by this activity. The gross value of production comprises growth of stock, animals sold for slaughter and net transfers of cattle between programme-areas. The quantification of production is a rather straight-forward procedure that consists of multiplying the number of animals (extracted for slaughter, transferred between programme-areas and increases in stock) by the average weight of each category (sex and age) and by market prices.

Employment, in its turn, is obtained by applying an exogenously defined coefficient to the cattle stock thus deriving labour requirements per animal.

c) The industrial sector comprises four branches of activity: mining, export, timber and other diverse industries.

The level of activity of the mining and export industries is defined exogenously and fed into the model as a policy objective. This treatment is justified by a lack of information with which to estimate behavioural equations and also because the Federal government has a strong influence in determining their level of operation either through tax incentives (export industry) or by granting concessions for mining.

Timber production is explained in the model as a linear function of the area deforested each year. This is the difference between the area devoted to agriculture and cattle raising in one year, as compared with figures for the previous year. Although this provides reasonable results in programme areas where the agricultural frontier is expanding it does not explain properly the situation in areas where agricultural expansion has come to a halt. In order to avoid this problem a lower constraint (value) was fixed for this variable.

By adopting a traditional economic base approach, the employment generated by other diverse industries is explained as a linear function of the urban population obtained from the demographic submodel.

Once the level of activity (added value) of each industrial branch is established, the level of employment is determined by means of the inverse of the average productivity of labour. In the case of diverse industries the employment generated is obtained from the behavioural equation and the added value is then obtained through the average productivity coefficient.

d) The fourth sector of the economic submodel comprises three activities: civil construction, commerce and services and government.

A lack of information has resulted in a very rough treatment of civil construction and government activities. In fact, the behavioural equations for explaining the added value of these sectors are mere hypotheses of linear functions fitted with only two observations. As such they cannot stand up to any statistical testing and must be regarded as assumptions underlying the model.

Commerce and services are assumed to constitute, together with diverse industries, the domestic (non basic) sector of the regional economy. It follows that their level of production is determined by the size of the local market. As in the case of diverse industries, total employment generated by commerce and services is explained in the model as a function of urban population. In this case, however, a simple linear function was utilized.

iii) Environmental and Physical/Infrastructural Submodel

In its present version this submodel forms a very marginal part of the whole model but fulfils two specific functions. Firstly, it is a means for explicitly introducing into the model the goals of a policy for the preservation of the environment in the form of norms for the use of natural resources. Secondly, it determines the investment entailed by the pursuit of social strategies simulated by the model.

This submodel provides a static consideration of environmental policies by introducing a set of constraints for agriculture and cattle-raising. This is done by means of a traditional methodology utilized in surveys of natural resources which leads to the determination of the activities best suited for each combination of soil quality, temperature and rainfall.

Since the agricultural sector of the economic submodel is mainly designed to explain the allocation of land to a few crops, environmental constraints are determined by the maximum area to be devoted to crops and pastures and the recommended carrying capacity of the latter. In this way, the adoption of productive practices derived from environmental policies such as techniques for conservation and improvement of land productivity, crop rotation practices, selection of adequate varieties of plants, etc., is assumed to be represented by coefficients of land productivity and the cattle/ pasture ratio.

Due to the fact that land productivity is defined exogenously and that land potential is fixed for a given technological level, environmental constraints were determined outside the model and then introduced as constraints.

With regard to the physical investment required for the attainment of social, spatial and infrastructural objectives, three basic components were distinguished: education, health and transportation.

The investment requirements of education and health services were calculated by a simple set of identities. The number of students per school and the size of the population to be served by each health facility were established. The net requirement of physical facilities for both education and health services was then obtained by comparing existing provision with that required to satisfy the projected population forecast by the demographic submodel. The stock of physical units increases each year, their number and location constituting policy objectives.

The most important type of transport investment in the region is the construction or improvement of rural roads. Because of this, the transport sector of the model refers exclusively to the expansion of the road network.

Since the road network was utilized as an independent variable for calibrating the behavioural functions of the agricultural sector, and since decisions on the allocation of resources for roads in

Brazil are usually taken by the Federal government, it was decided that this sector of the model should assess the priority to be given to alternative road projects. This sector of the model contributes to define the way in which an exogenously defined amount of resources will be allocated to road investments.

The present version of this sector of the model is the outcome of a research project carried out by GEIPOT (Brazilian Transports Corporation) sponsored by the World Bank. It is based on the producer surplus method for appraising road projects, and its estimation is linked to Von Thunen's agricultural location theory. To the extent that the function of this transport sector is to give priority to road projects it has no direct relationship with the rest of the model (the agricultural sector utilizes the extension of the existing road network measured in kilometers and civil construction uses the amount of investment in roads) it was judged preferable to run it independently from the model and to introduce its results through the policy variables of agriculture and civil construction.

Thus, after deciding that the transportation and environmental sectors will be processed independently, the environmental and physical/infrastructural submodel was reduced to a few identities concerned with physical investments in education and health, and with environmental constraints on agriculture. In order to simplify the computer programme the education and health sectors were included in the programme of the composite model thus avoiding a separate submodel, and the environmental constraints were included in the agricultural section of the economic submodel.

iv) The composite model

The composite model integrates the various submodels, drawing together their results to provide a coherent view of the behaviour of the regional socio-economic system. It also provides certain indices for assessing both the feasibility of the strategies simulated and their expected impact on the regional system.

Since each submodel and even each sector of the economic submodel was constructed and estimated independently, their integration entails some theoretical and practical problems.

On the one hand the composite model has to deal with the control of the procedures used for transferring variables between submodels (and between sectors) as well as from one year of the simulation period to the next. These transfers constitute one of the basic characteristics of the whole model since they make the model "cybernetic", i.e. different from a purely linear additive model, in which sectors are separable and the whole is simply the sum of the parts. Thus designing and monitoring such relationships becomes a central part of the modelling process since they are responsible for the way in which the model reproduces the dynamic behaviour of the regional system.

A detailed description of these transfers of variables and the way they are monitored is presented in Chapter 7 and Appendix III.

On the other hand, there is a problem of aggregation. This involves both the aggregation of sectorial variables to generate global results and the aggregation of subregional variables to generate regional ones. In the former case there are difficulties with the conceptual differences of the variables estimated in each submodel or sector. An example of this problem is represented by the fact that the agriculture and cattle-raising sectors generate estimates of gross value of production and direct employment (indirect jobs such as that involved in administration tasks are neglected) while the other sectors lead to estimates of added value and of total employment. Thus to obtain estimates of these variables for programme areas (or the whole region) some adjustments are required. In these cases special coefficients are applied to the variables generated by the agriculture and cattle-raising sectors in order to make aggregation possible.

The aggregation of subregional variables to obtain regional estimates requires a careful consideration of the conceptual content of the variables involved. For example, net migration is quantified at the programme area level. This means that a person coming to programme area A from another area of the region is treated in the same way as a person coming from another region. In this way the aggregation of net migration will be an overestimate at the regional level as it includes flows of people that constitute intra-regional migration.

3.3.3 Model Estimation and Validation

The composite model contains 101 equations, 19 of which are behavioural, the rest being identities or definition equations. On the whole they comprise endogenous variables, lagged endogenous, exogenous and policy instruments.

Behavioural equations were quantified by means of the ordinary least squares method (OLSQ) which yield acceptable results (except three equations that required the use of a special procedure for eliminating serial correlation in the error term). Since the model has no simultaneous behavioural equations it was not necessary to use two stage or three stage least squares methods.

Utilization of OLSQ leads to a behavioural equation of the following form:

$$Y = a_o + a_1X_1 + a_2X_2 + E$$

Where

Y = dependent variable

X_1X_2 = independent or explanatory variables

$a_0a_1a_2$ = parameters

E = error term

E comprises three basic sources of error. They are error to the linear approximation of some other implicit functional form, variation in the dependent variable not explained by the dependent variables utilized, and the combined influence of some non-measurable variables. For practical purposes E is assumed to be a random variable following a normal distribution with zero mean and constant variance ($N(0,\sigma^2)$).

The presence of E in any behavioural equation implies that the function is probabilistic (as opposed to a deterministic mathematical function). This means that the proper use of this function for predictive purposes requires the determination of a confidence interval for the forecast variable.

In simulation experiments, instead of a confidence interval a random variable, generated by special computer sub-routines is used. Thus exogenous variables (including those utilized as policy instruments) are given precise values and the model is run for a defined period. For each run of the model the computer prints a series of values taken by the endogenous variable in each time period. By running the model several times (with the same set of values for the endogenous variables) a sample of the time series is obtained. These series differ according to the effect of the random variable utilized for simulating the error term.

The sample is then studied by means of standard statistical methods to make inferences about the overall behaviour of the system in question. This data analysis in simulation experiments is usually carried out by means of analysis of variance (*). Naylor (NAYLOR, 1971; pp. 29=34) suggests that for special cases of analysis of variance it is necessary to use the F-Test, multiple comparisons, multiple rankings, spectral analysis, sequential

(*) Regression Analysis can be used in absence of qualitative factors.

sampling or nonparametric methods.

In our case the model contains 19 endogenous variables quantified by a similar number of behavioural equations. These variables are used in a number of identities either as additive terms or multiplied to other variables. The new values obtained from such identities are frequently used as lagged endogenous variables in successive years of the simulation.

The inclusion of the error term in each behavioural equation can be expected to lead to uncontrollable results in the simulation of the composite model. In fact, since such error terms are summed and even multiplied many times in each simulation, the final error of the model may become so big that the results would become highly unstable.

In order to avoid these problems and also to make the use of the model easier, error terms (or random variables) were omitted (*). In this way, the model becomes deterministic. That is, for each set of values for exogenous variables the model generates only one set of results which does not allow any test of statistical significance.

Although the supression of random variables can be regarded as a limitation of the model, the advantages provided by such a procedure in terms of operationality and stability are adequate compensation.

To the extent that our model is to be used for deterministic simulations its results are to be regarded as conditional statements

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(*) Suppression of random variables in a linear model does not constitute a problem for simulation purposes since the expected mean of such variables is zero. Thus the mean of a big sample would tend to be equal to the results of deterministic simulations. When the model has non linear functions omission of random variables is to be regarded as a source of differences between the expected mean and deterministic results.

of the expected regional situation for a given set of exogenous variables and policy instruments. It follows that a sensitivity analysis of parameters, exogenous variables and policy instruments is required for assessing both the stability and quality of the model's results.

With regard to validation it is necessary to bear in mind that a model is a complex hypothesis about the structure or behaviour of a given system. In the case of a simulation model comprising a large number of functional relationships (each of which represents a specific hypothesis) its complexity is so big that traditional statistical techniques become inadequate for properly testing the whole set of hypotheses.

Thus, when modelling complex systems it is preferable to use validation instead of statistical testing. Underlying this practice is the idea that the concept of validation has a less rigorous connotation than the statistical testing of hypotheses.

Validating a model implies the use of a set of special procedures that enable the researcher to determine if the model is a reasonable approximation to the real system it is designed to represent, if its results are acceptable, etc. In this way, the validation of a model may lead to the conclusion that either it is satisfactory for the purpose it is designed to serve, or that further study and improvement of the model is required.

From another point of view it is necessary to bear in mind that model validation is a lengthy and complex process which involves at least two basic stages. The first step consists of determining if the model is consistent in a logical and programming sense. The second step refers to the determination of the extent to which the model represents the phenomena it should represent, in other words, this second step involves the generation of a set of variables that could be compared to empirical observations. (See GOLDBERGER, 1964; Holt (HOLT, 1965)).

The first step usually requires a set of simulation runs specially designed for detecting errors in the logical structure of the model.

To verify if the model adequately represents real world phenomena (second step) it is necessary to simulate the model and to compare its output with available empirical observations. Appendix III contains the outcome of the validation of the model and also a sample of the sensitivity tests carried out.

3.4 REVIEW OF OTHER REGIONAL MODELS

In specifying the structure of the model, some concepts and elements of a number of available simulation models were utilized.

In fact our model owes a great deal to Forrester's Industrial Dynamics and Urban Dynamics Models, to Hamilton's Susquehanna River-Basin Simulation Model, to Fullerton and Prescott's Economic Simulation Model for Regional Development and to the Simulation Model for Agriculture in Nigeria developed by Michigan State University. It also incorporates some elements of sectorial models developed in Brazil.

Forrester's Models (FORRESTER, 1961 and 1969) and Naylor's reader on the design of simulation experiments (NAYLOR, 1969) provided us with a good introduction to the methodological background of model simulation. Their contributions were very helpful in the initial stages of modelling when decisions regarding the overall structure of the model, type of feedback loops, relationships between submodels, etc. were required. Although Forrester's work constitutes the main source of inspiration for formulating a simulation model for the Upper Paraguay River Basin, its current version shows greater similarity with other models also inspired by his pioneer work in dynamic simulation.

Because of the similarity of objectives, the study of the Susquehanna River Basin undertaken by the Battelle Memorial Institute (HAMILTON et al, 1969) and the economic simulation model for regional development carried out by Fullerton and Prescott (FULLERTON and PRESCOTT, 1975) heavily influenced the structure of our model. Because of this, a deeper review of these models is presented below.

Another simulation model reviewed in our work is the model for agricultural sector analysis developed by a team from the Michigan State University for Nigeria. This model was the outcome of a Research project financed by AID (Agency of International Development). Its main design objective was "to develop an aggregate model (useful in many countries), capable of being partitioned and extended to include additional, detailed submodel components which would handle more detailed decision making and policy problems of concern to agricultural development agencies", (JOHNSON, G. et al, 1971; p.3).

The outcome of such an ambitious project was a very complex model, composed of four major submodels, hardly compatible with the restrictions of statistical data that characterize under-developed countries. For our purposes, however, it provided a useful insight into some problems affecting agriculture and cattle raising in tropical countries and also of the way they can be modelled.

As mentioned above, some Brazilian sectorial models were also utilized in the modelling process. The cattle-raising sector of our model was improved by some elements of the simulation model for cattle-raising in the swampy area of Mato Grosso (EMBRAPA, 1978) and of the econometric model of beef cattle in Brazil (MASCOLO, 1980). In fact, the first model provided a very good explanation of the factors affecting the evolution of the cattle stock in Mato Grosso while the second inspired the inclusion of the relationship between extraction rates and expected market prices through the cattle-cycle mechanism.

The transport sector of the model was developed by the Brazilian Transport Planning Corporation as part of its research project on the impact of local roads (GEIPOT, 1981). Here, the main conceptual contribution concerns the utilization of the producer surplus approach for evaluating the impact of road projects in areas where current traffic is low and where the project is expected to induce an increased level of economic activity.

3.4.1 THE SUSQUEHANNA RIVER BASIN MODEL

Sponsored by a group of electricity utility companies interested in the economic development of the Susquehanna River Basin, in 1962 the Battelle Memorial Institute set up a four year research project aimed at developing and refining a new methodology for the better understanding of regional and water resource phenomena in that basin.

These studies involved the formulation of a computer simulation model of the basin. Such a model was designed for serving the following objectives:

a) to determine the future adequacy of water resources in the region and what factors might alter demand;
b) to assess the extent of future needs for dams and other facilities affecting the quantity and quality of water available;
c) to estimate the impact that various proposed systems of river works might have on the economy of the Susquehanna River Basin.

Since traditional analyses of federal water resource development programmes are based upon long-term projections of fifty or more years, in order to assure comparability with such analyses the model was designed to simulate the regional system over periods of fifty years.

The model comprises three sectors dealing with demographic, employment and water resources.

The demographic sector is composed of a cohort survival model for population forecasting that includes behavioural equations explaining birth rates as a function of unemployment rates, net migration rates in terms of unemployment rates and the reciprocal of population, and participation rates as a function of employment and population ratios. Death rates are defined exogenously because of their low incidence in explaining regional demographic behaviour.

The employment sector explains the behaviour of the regional economy in terms of job supply. The model omits variables such as income, value added or output. This sector of the model is based on the export-base theory and distinguishes three major groups of economic activity: export industries, business serving activities and household serving ones. This theoretical framework is complemented by Isard's industrial location theory which enables the classification of these groups of economic activity in relation to the factors influencing their location in the region. The factors considered were, access to market, access to raw materials and production costs including wages.

In this way, household and business serving activities are assumed to be oriented to regional markets. Consequently, growth of employment in household serving activities is explained as a linear function of total population of each sub-region and that of business serving activities as a linear function of the employment generated by the other sectors of subregional economies.

Both functions are quantified by means of ordinary least squares performed on a sample of eight cross section observations for 1960.

Export activities in their turn comprise manufacturing industries, mining and agriculture. In a special category are government, education and military services. The model refers primarily to manufacturing industries, treating the other activities separately (exogenously). Manufacturing industries were further classified into four groups that were relatively homogeneous with respect to the importance of the three locational factors defined. Thus the following groups of activities were established: capital-intensive processors, labour-intensive processors, durable fabricators and nondurable fabricators.

The rate of growth of employment generated by these activities is explained as a function of market growth and relative costs. Relative cost indices incorporate measures of the weighted importance of the different factors of production (labour, transportation and capital) to each industry group. These weights are combined with measures of the relative cost of obtaining these factors in the region. These indices are adjusted up or down in relation to a low- or high-cost subregion by an amount proportional to the cost elasticity of each industrial group. Market growth-rates, in their turn, constitute an exogenous input of the model.

Finally, the water sector is defined as a technical sector designed for simulating the conditions in the river relating to both water quality and quantity. It has a partial scope excluding some aspects of water resource development such as navigation, irrigation, hydropower and flood control.

Feedback loops link the demographic and employment sectors and each sector affects the water sector separately. Possible feedback from the water sector to economic growth in the basin was excluded because it was judged negligible. The model is disaggregated into eight subregions and typical runs were designed for simulating 50 year periods.

The model's equations were written using the DYNAMO notation. DYNAMO is a special compiler that translates a model, from an easily understood equation language using simple mnemonics to machine language, runs the model and produces tabulated and plotted results. The model is estimated using conventional econometric techniques such as ordinary least squares but it was necessary to design quite complex procedures for quantifying access factors that are included in the relative costs indices.

On the whole more than 200 major simulations on the model are reported and a number of experiments were conducted for testing specific properties of the model and also for testing the model's validity.

Although no explicit test of the overall performance of the model is reported, partial sensitivity tests lead to the impression that the model's results are reasonable, stable and significant.

As far as the formulation of our model is concerned, the experience of the Susquehanna study was both highly suggestive and very useful for solving some practical problems. In general terms it provides a good orientation for the whole modelling effort, especially with regard to the iterative nature of model building, the way to handle the spatial disaggregation problem, and the design of sensitivity tests, etc. Specifically, the type of behavioural equation used for household serving employment was taken and used for explaining the behaviour of diverse industries and of commerce and services.

3.4.2 THE IOWA STATE MODEL

This model was developed by Herbert Fullerton and James Prescott of the Iowa State University for providing projective economic and demographic information for the State of Iowa and for various preselected combinations of its contained subareas.

It is the outcome of a research project aimed at extending the information base for regional planning in the state subject to the constraint of spatial and temporal consistency between the reference economy (the State) and its smaller components (countries and cities).

The specific objectives of the study were defined as follows:

1. Construct a balanced simulation model of the recursive type, which can be used to provide projective economic and demographic information for the reference region and alternative combinations of its subareas (river basins, economic areas and critical demand areas).

2. Determine the extent to which indices of impact and development are sensitive to selected data and policy related alternatives.

3. Determine the extent to which these indices are influenced by alternative subarea delimitations (FULLERTON and PRESCOTT, 1975; pp.7, 8).

The result was a dynamic simulation model of the deterministic type containing six major component sectors comprising 90 computer equations altogether.

The model can be broken down into major component sectors or blocks which can be simulated in isolation. Naturally, for partial simulations, values for the exogenous and lagged endogenous variables generated by other sectors must be provided.

The model is recursive. This is to say that time-lagged and sequential dependence occurs among variables within and among component sectors. Model outputs become model inputs in the recursive sequence from block to block and from one time period to the next.

Another characteristic of the model is that its forecasts are balanced spatially. Aggregate model outputs are obtained by summation where they are generated at the standard area level.

Conversely, spatially disaggregated model outputs generated at the reference area level are forced to be consistent with their aggregated counterpart.

As mentioned, the model comprises six major component sectors: demographic, interindustry, capital, labour, income and water sectors.

The demographic sector is composed of a traditional cohort survival structure containing only one behavioural function for determining net migration rates. They are explained as a linear function of the net employment effect, the proportion of employment in service activities and locational influences. This last variable is characterized by means of two dummy variables, one indicating the presence in the standard area of a city with a population of 10.000 in 1960 and the other indicating the presence of a major educational institution. Fertility and mortality rates are defined exogenously and the transition among cohorts is assumed to be equal to one-fifth of the population in any given cohort.

The model produces annual population forecasts for 120 standard areas disaggregated by sex and 16 age cohorts for a twenty-year period.

In the interindustry sector, structural characteristics of the reference economy are depicted in an input-output framework. This sector comprises 15 interacting industries and five categories of final demand with associated primary inputs, gross outlay and gross output.

Final demand is composed of personal consumption expenditures, capital accumulation, Federal Government expenditures, exports and state and local government expenditures.

Transactions, direct purchases and direct and indirect requirement matrices were estimated for the state economy in 1960. The technical structure of the regional economy represented by the matrix of direct and indirect requirements is assumed to be constant for the whole simulation period.

The capital sector estimates gross investment, depreciation on capital stock and capital accumulation. These variables are estimated for the regional economy on a sectorial basis, starting from the projected levels of activity provided by the input-output model. Such projected levels of activity are transformed into sectorial requirements of capital by means of capital-output ratios. Gross investment is then determined by subtracting the existing stock of capital from sectorial requirements and adjusted by depreciation of current stock.

In the labour sector, estimates of the available labour force (supply) and the required labour force (demand) are calculated. Labour supply is determined by applying participation rates to the population forecasts provided by the demographic sector. Labour demand estimates are calculated at both the state and standard area levels. These estimates are based on realized gross output and output-employee ratios at the state level and on industry occupational profiles for standard areas. With these estimates unemployment rates are determined for the regional economy.

The income sector provides estimates of total personal income, disposable income, per capita disposable income, per capita personal income and added value, at both the state and standard area levels. This part of the model is merely an accounting framework without any behavioural equation.

Finally, the water sector determines the water requirements for human and industrial consumption for the whole region and for each standard area.

Initial simulations of the model revealed two main problems. On the one hand, the model generated disparate growth rates in labour supply and demand after 1970. Labour demand rose at such a rapid rate, that after 1975 the model generated negative unemployment (*). For solving this problem an upper bound was placed on investment demand establishing a maximum rate of growth per year of 15% including depreciation. Such a constraint also dampened growth rates in per capita disposable income because this variable is indirectly dependent on investment demand. On the other hand net migration rates tend to underestimate positive immigration for population between 15 and 34 years of age in standard areas with major educational institutions. In order to solve this problem, net migration rates for these cohorts were multiplied by an adjustment factor for the standard areas with special educational infrastructure.

After these adjustments the model output became satisfactory from a theoretical point of view and consistent with available empirical data.

The experience of the Iowa state model was very helpful in the formulation of our model. In fact the structure of the demographic sector was adopted and applied with small variations. Perhaps the most significant difference between this sector and our demographic submodel is the structure of the behavioural function for explaining net migration rates.

The determination of labour force, the demand for labour and unemployment rates are also calculated in rather similar ways. Another significant contribution obtained from the Iowa model

(*) This problem also occurred in the Upper Paraguay River Basin Model. See Appendix III.

was the use of special constraints for restoring the equilibrium of aggregate forecasts.

CHAPTER FOUR

DEMOGRAPHIC AND EMPLOYMENT SUBMODEL

4. DEMOGRAPHIC AND EMPLOYMENT SUBMODEL

This chapter describes the demographic and employment sectors of the composite model. This, like any other part of the model is composed of two types of relationships, namely identities and behavioural equations. The former are conceptual definitions, expressed in mathematical terms, regarding the way in which two or more variables are related.

Behavioural equations, on the other hand, are mathematical functions that define the value of some critical variables in terms of policy instruments or exogenous variables and are quantified by standard econometric methods.

The demographic and employment submodel predicts the volume and composition of regional population and derives the number of jobs that satisfy the utilization of the regional availability of human resources, given an exogenously defined employment policy.

For ease of exposition the demographic and employment sectors of this submodel will be presented separately.

4.1 THE DEMOGRAPHIC SECTOR

As is widely known, population growth is the outcome of three basic processes: births, deaths and migration. The contribution each of these processes makes to explaining population changes varies according to the size of the area and the volume of population under consideration.

In fact, when predicting the behaviour of big populations, let us say of a country, great care should be taken in the analysis of natality and mortality. Conversely, net migration becomes a crucial factor when attention is focussed on small areas. This accounts for the fact that, on the one hand, births and deaths are proportional to the volume of population, and obviously acquire greater importance as the population base increases.

On the other hand, it has been empirically demonstrated that there exists an inverse relationship between the number of migrants and the distance of their movements (ISARD, 1960). This empirical relationship leads us to the conclusion that as the size of the region under study increases the importance of interregional migration for explaining population growth decreases since, for a constant propension to migrate, a greater proportion of such movements will take place inside that region.

A quick look at the demographic behaviour exhibited by the states of Mato Grosso and Mato Grosso do Sul will reveal that net migration constituted an important factor in population growth. It represented more than 34% of total growth in both states during the sixties and 39% in the seventies, involving nearly 600,000 persons in the last twenty years (see tables 4.1 and 4.2). Although net migration rates for that period are lower than those of vegetative growth (birth rates minus death rates), their importance for prediction lies in the fact that they show great differences between programme areas while natural growth is fairly stable for whole region. Thus, any attempt to explain the spatial behaviour of regional demographic dynamics requires a close look at migration.

TABLE 4.1

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

TOTAL POPULATION 1960 - 1980

PROGRAMME AREAS	1960	1970	1980
1) ALTO PARAGUAY	21,031	50,027	91,974
2) CÁCERES	27,726	85,699	161,878
3) CUIABÁ	157,148	222,687	477,171
4) RONDONÓPOLIS	70,978	170,029	200,409
5) BARRA DO GARÇAS	31,423	52,350	122,670
6) DIAMANTINO	11,909	18,089	94,208
STATE OF MATO GROSSO	320,215	598,881	1,148,310
7) ALTO TAQUARI	34,537	65,732	85,933
8) CAMPO GRANDE	112,400	199,171	352,680
9) BODOQUENA	56,174	78,500	94,862
10) CORUMBÁ	95,651	118,382	124,138
11) TRÊS LAGOAS	80,023	136,899	163,673
12) DOURADOS	193,413	399,547	540,309
STATE OF MATO GROSSO DO SUL	572,198	998,231	1,361,595
UPPER PARAGUAY RIVER BASIN	575,645	990,227	1,589,045

SOURCE: FIBGE, 1960, 70, 80

TABLE 4.2

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

COMPONENTS OF DEMOGRAPHIC GROWTH 1960 - 1980

(CUMMULATIVE ANNUAL RATES - %)

PROGRAMME AREAS	1960 - 1970			1970 - 1980 (*)		
	GROWTH RATE	NATURAL GROWTH RATE	NET MIGRATION RATE	GROWTH RATE	NATURAL GROWTH RATE	NET MIGRATION RATE
1) ALTO PARAGUAY	9.05	3.16	5.89	6.28	2.60	3.68
2) CÁCERES	11.95	3.64	8.31	6.56	2.60	3.96
3) CUIABÁ	3.54	3.60	- 0.06	7.92	2.60	5.32
4) RONDONÓPOLIS	9.13	3.47	5.66	1.66	2.60	- 0.94
5) BARRA DO GARÇAS	5.24	3.42	1.82	8.89	2.60	6.29
6) DIAMANTINO	4.27	3.31	0.96	17.94	2.60	15.34
STATE OF MATO GROSSO	6.46	3.52	2.94	6.73	2.60	4.13
7) ALTO TAQUARI	6.65	4.13	2.52	2.72	2.60	0.12
8) CAMPO GRANDE	5.89	3.74	2.15	5.88	2.60	3.28
9) BODOQUENA	3.40	3.48	- 0.08	1.91	2.60	- 0.69
10) CORUMBÁ	2.16	3.60	- 1.44	0.48	2.60	- 2.12
11) TRÊS LAGOAS	5.52	3.53	1.99	1.80	2.60	- 0.80
12) DOURADOS	7.52	3.49	4.03	3.06	2.60	0.46
STATE OF MATO GROSSO DO SUL	5.72	3.60	2.12	3.15	2.60	0.55
UPPER PARAGUAY RIVER BASIN	5.57	3.52	2.05	4.84	2.60	2.24

(*) PRELIMINARY ESTIMATES

These quite general ideas constitute a set of basic criteria for designing a demographic model or for selecting one from the wide variety offered by demography. In our case this second approach was adopted due to the fact that satisfactory formulations are available with the advantage of having already been tested. After analysing several types of models (*) it was decided that the most suitable ones for the purposes of the thesis were those based on the cohort-survival method.

There are two main reasons for such a selection. On the one hand this type of model enables a high degree of disaggregation of the variables explaining the demographic behaviour, and this makes the determination of the interrelationships with the other submodels easier. On the other hand it provides highly detailed information regarding the sex and age structure of population for each forecasting period, urban and rural conditions, etc, which is of great importance for regional planning purposes, since it improves the accuracy of policy formulation, especially in aspects such as education, health, housing, etc.

Cohort-survival models forecast the population of an area by disaggregating the total base year population into several age-strata (cohorts), each of which is adjusted by inflows (births and immigration) and outflows (deaths and emigration) as well as by the ageing process during the forecasting period.

The model adopted is similar to that used by Fullerton and Prescott (FULLERTON and PRESCOT, 1975), distinguishing male and female populations which are further disaggregated into 15 cohorts of five years each. It is calibrated for each programme area and its general formulation comprises ten identities and seven behavioural equations. Let us now examine them in turn.

(*) See, for example Rees and Wilson (REES and WILSON, 1973); Wilson (WILSON, 1974); Rogers (ROGERS, 1966, 1968); Stone (STONE, 1967).

4.1.1. Identities

Total population of a given programme area for year "T" can be expressed as the sum of all cohorts for both sexes in that year.

$$\text{(DEM - 1)} \quad POP\ (A,T) = \sum_{S=1}^{2} \sum_{E=1}^{15} POP\ (S,E,A,T)$$

Where

POP (A,T) = Total population, programme area "A",year "T".

POP (E,S,A,T) = Population sex "S", age group "E", programme area "A", year "T" (*)

The population in any age group (E) of each sex (S) in year "T" will be composed of all those belonging to that cohort the previous year, plus those entering the age group (E) in year (T) minus those entering the upper cohort that year minus those who die, plus the effects of net migration. Deaths are expressed by means of survival rates. Thus we can write:

$$\text{(DEM-2)} \quad POP\ (S,E,A,T) = \left[POP\ (S,E,A,T-1)+GI\ (S,E,A,T)-GO\ (S,E,A,T)\right] * SUR(S,E,T) + NMIG(S,E,A,T)$$

Where

GI(S,E,A,T)=Population passing from cohort E-1 to E in year T

GO(S,E,A,T)=Population passing from cohort E to E+1 in year T

SUR(S,E,T) =rate of survival,sex S, cohort E, year T (survival rates are equal for all programme areas)

NMIG(S,E,A,T) = net migration sex S, cohort E, programme are A, Year T.

(*) Age cohort: E=1 (0-4 years)
E=2 (5-9 years)
⋮
E=14 (65-69 years)
E=15 (70 years and over)

Sex: S=1, Male; S=2, Female

The population entering the first cohort is composed of all those who were born during the year. The number of births is obtained by multiplying the female population within the limits of child-bearing age groups in the previous year by specific fertility rates. Since mortality is usually very high for children under one year of age a specific survival rate is applied to the number of births. Finally, surviving children are disaggregated by sex using a masculinity rate. Thus, population entering the first cohort becomes:

$$\text{(DEM-3)}\quad GI(1,1,A,T) = \sum_{E=p}^{q} POP(2,E,A,T-1)*FERT(E,T)*MASR*BSUR(1,T)\text{, and}$$

$$\text{(DEM-4)}\quad GI(2,1,A,T) = \sum_{E=p}^{q} POP(2,E,A,T-1)*FERT(E,T)*(1-MASR)*BSUR(2,T)$$

Where

FERT(E,T) = rate of fertility

p,q = age-group limits for the child-bearing cohorts (*)

MASR = rate of masculinity at birth

BSUR(S,T) = rate of survival for children under one year of age, sex S, Year T.

The number of persons entering the other cohorts (i.e. all except the first one) is assumed to be one fifth of the population in the previous age group during the year T-1. Although it can be argued that population is not homogeneously distributed between the ages comprising a cohort, this assumption was adopted for simplifying calçulations. As a matter of fact, this assumption involves an overestimation of the number of persons entering one cohort for a one-year forecast since, within any cohort, the size of the population decreases as age increases. However, this overestimation in a one year forecast is compensated by the

(*) It was assumed that the child-bearing age varies from 15 to 49 years of age. Thus p=4 and q=10.

overestimation of the population leaving the cohort. For forecasting periods equal to the amplitude of the age group interval (5 years) this problem almost disappears because all cohorts (except the last) are wholly transferred to the next age group. This gives us:

(DEM-5) GI(S,E,A,T) = POP (S,E-1,A,T-1)/5
$E \neq 1$

Similarly, population leaving any cohort (except E=15) becomes:

(DEM-6) GO(S,E,A,T) = POP (S,E,A,T-1)/5
for E=1, 2, ... 14

(DEM-7) GO(S,E,A,T) = 0
for E=15

Net migration, in its turn, is obtained by multiplying the population of each sex and age cohort in the previous year by a net migration rate.

(DEM-8) NMIG(S,E,A,T) = POP(S,E,A,T-1)*NMR(S,E,A,T)

Where

NMR(S,E,A,T) = rate of net migration, sex S, age group E, programme area A, Year T

Finally, rural and urban components are determined by using a rural coefficient which is allowed to vary through time.

(DEM-9) POPR(S,E,A,T) = POP(S,E,A,T)*RC(A,T), and

(DEM-10) POPU(S,E,A,T) = POP(S,E,A,T) - POPR (S,E,A,T)

Where

POPR(S,E,A,T) = rural population, sex S, age group E, programme area A, Year T

POPU(S,E,A,T) = urban population, Sex S, age group E, programme area A, Year T

RC(A,T) = rural coefficient, programme area A, Year T.

4.1.2. Behavioural Equations

In strict academic terms the demographic sector of the model should contain a function for explaining each one of the processes affecting the population of a given cohort, i.e. birth rates, survival rates, net migration and the variation of the urban/rural coefficient.

Birth and survival rates will probably vary during the period for which the composite model will be used. Therefore, equations predicting their future behaviour should be introduced into the submodel in order to dynamize it. The specific shape of such equations should be determined by regression analysis of historical data or by correlation with other relevant variables. Lack of information made the specification of these functions impossible in our case, but available estimates of such rates based on empirical studies were adopted as reasonable substitutes. Thus fertility rates were taken from Costa (COSTA, 1976) while survival rates were extracted from United Nations Life Tables (UNO,1978).

For the reasons given above, especial effort was made to formulate and specify the explanatory functions of migration and also those of the process of urbanization.

Before discussing the specific functions let us examine some of the basic features of these processes.

Migration has been considered within the context of regional analysis in many different ways. Isard (ISARD, 1960;ch. 2), groups the basic methods of migration forecasting into two broad categories: projection of historical trends, and theoretical models.

The first category includes a wide variety of statistical procedures which do not explain the cause-effect relationships that generate migration, but enable the estimation of future migration by mathematical methods.

Theoretical methods, on the other hand, emphasize the explanation of the underlying forces that govern migration and by forecasting the future behaviour of these forces (which become independent variables) it is possible to estimate the main features of future migration. Obviously, this second approach is more useful in our situation.

Siebert (SIEBERT, 1969) explains migration (he refers explicitly to mobility of labour) as the final stage of an individual's process of information gathering and decision making. The elements considered in this process are basically:

i) Level of dissatisfaction with regard to the socio-economic environment;
ii) Level of information about the situation in other areas;
iii) Search processes and migration decisions;
iv) Degree of mobility.

Siebert's approach is very clear, logical and comprehensive, but it requires a large quantity of data, most of which is very difficult to estimate.

For this reason a simpler set of explanatory relationships will be adopted in accordance with the scheme developed by Hamilton and his colleagues (HAMILTON et.al., 1969) who explain migration as a function of the relative availability of jobs at the regional scale.

Although the relationship between employment and net migration is perfectly obvious, the direction of such a cause-effect relationship could be regarded as dubious. In fact, it is possible to argue that some areas (especially metropolitan regions) may exhibit growth in total employment as a consequence of the extraordinary growth of their internal markets induced by immigration.

In this case the growth of total employment is clearly a consequence of net migration and not its cause. Although this is a valid argument it is likely to be true only for explaining the growth of commerce , service industries and some other activities heavily influenced by the size and behaviour of local markets (non basic activities as defined by the economic-base theory), since development of export activities or heavy industries depends on a wider set of variables.

Recent economic growth of the study area, however, is based on the expansion of primary activities and was strongly induced by official policies (see Section 3.2.2). As public incentives were granted basically for expanding the agricultural frontier it can be safely assumed that, at least during the last twenty years, the growth of basic activities has attracted population to the states of Mato Grosso and Mato Grosso do Sul, and not the contrary.

This assumption is also useful since it permits the quantification of future migration as a consequence of the achievement of the employment goals defined for each programme area. In spite of accepting this cause-effect relationship for explaining net migration, the economic sector of the simulation model also accounts for the induced economic effects resulting from the concentration of population by using urban population as an independent variable that determines the level of activity of some urban sectors (see Sections 5.4 and 5.5).

The first problem in specifying the net migration function is the specification and quantification of the dependent variable. Migration in a defined area comprises two flows of people, those entering and those leaving the area in a given period. Since in open regions there is no written record of such movements, the only feasible way to estimate these flows is by a comparison of two censuses. If the information is adequately disaggregated, estimates of immigration and emigration can be performed independently. In our case available information only made possible the estimation of net migration (immigration minus emigration) for the period 1960-1970 (*).

The estimation process began by forecasting base year population by sex and age-strata with observed birth and death rates. This leads to an "expected population" for each programme area in 1970. Net migration (by sex and age cohort) was obtained by subtracting this expected population from that of the 1970 census, and then converting it into accumulative annual rates. For simplicity, age-strata were grouped into three categories (0-14; 15-49; 50 and over).

The independent variable was defined as the rate of growth of total employment during 1960-1970 (**) (see table 4.3). Thus by means of regression analysis on cross-section data for 12 programme areas, six explanatory functions were obtained which showed a considerable statistical consistency (see table 4.4).

(*) Quantifying the net migration function for the period 1970-80 was rather hazardous because there is no reliable information regarding actual birth and death rates nor about employment for this period. These data will only be available when the findings of the 1980 census have been completely processed. In spite of this limitation the function was calibrated for the period 1960-70 and then tried in the model for predicting the population for 1980 with satisfactory results.

(**) Four independent variables were tried. After analysing the regressions obtained the rate of growth of total employment was selected.

TABLE 4.3

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

NET MIGRATION AND TOTAL EMPLOYMENT GROWTH RATES (1960-70) (*)

PROGRAMME AREAS	MALES NET MIGRATION RATES			FEMALES NET MIGRATION RATES			EMPLOYMENT GROWTH RATE
	0-14	15-49	50 and over	0-14	15-49	50 and over	
1) ALTO PARAGUAY	6,12	6,68	2,89	6,13	5,66	3,26	8,4
2) CÁCERES	8,55	8,75	8,61	8,70	7,54	5,21	12,7
3) CUIABÁ	-0,55	0,68	0,04	-0,44	0,11	-0,35	3,3
4) RONDONÓPOLIS	5,91	6,14	3,85	5,92	5,34	3,53	9,2
5) BARRA DO GARÇA	1,70	2,92	-0,42	1,92	1,47	-0,12	4,7
6) DIAMANTINO	1,22	1,62	-4,02	1,74	0,54	-1,16	3,1
STATE OF MATO GROSSO							
7) ALTO TAQUARI	1,62	3,14	2,34	2,44	2,31	0,04	6,5
8) CAMPO GRANDE	1,06	2,92	2,86	1,19	3,07	2,35	5,8
9) BODOQUENA	-0,10	0,31	-0,13	-0,01	-0,49	-0,24	3,2
10) CORUMBÁ	-2,17	-0,70	1,83	-2,12	-1,39	-1,74	2,0
11) TRÊS LAGOAS	1,81	2,47	1,61	1,80	2,08	0,79	5,3
12) DOURADOS	4,38	4,12	3,27	4,52	3,45	2,28	7,2
STATE OF MATO GROSSO DO SUL							
TOTAL REGION							

(*) All rates are annual and compound

TABLE 4.4

STUDY AREA: NET MIGRATION FUNCTIONS (*)

	Dependent Variable NMR(S,E, A)	Intercept	Independent Variable CREMP(A)	F	R^2
(DEM-11)	MALES 0-14 NMR(1,E,A) E=1,2,3	-3,336 (-5,33)	0,974 (10,33)	106,79	0,91
(DEM-12)	MALES 15-49 NMR(1,E,A) E=4,....10	-1,997 (-4,73)	0,883 (13,88)	192,52	0,95
(DEM-13)	MALES 50 & over NMR(1,E,A) E=11,..15	-3,046 (-2,75)	0,831 (4,98)	24,82	0,71
(DEM-14)	FEM.0-14 NMR(2,E,A) E=1,2,3	-3,103 (-5,01)	0,967 (10,37)	107,57	0,91
(DEM-15)	FEM.15-49 NMR(2,E,A) E=4,...10	-2,606 (-6,74)	0,854 (14,66)	215,02	0,96
(DEM-16)	FEM.50 & over NMR(2,E,A) E=11,...,15	-2,756 (-5,93)	0,657 (9,39)	88,11	0,90

N.B. : Values in brackets correspond to the "t" statistics (student test)

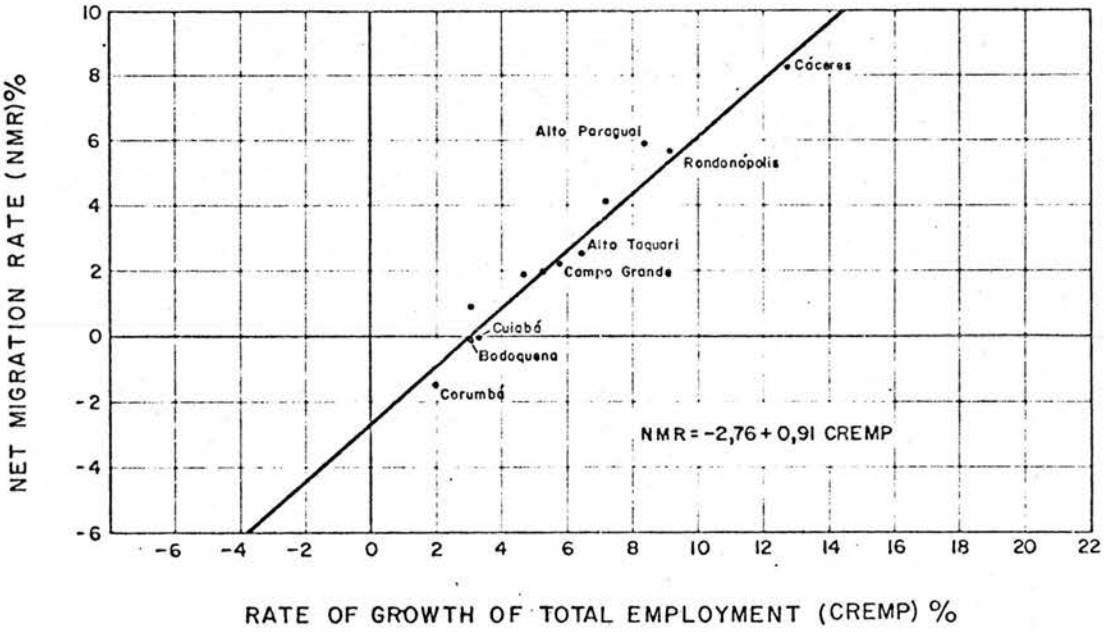
(*) Although these functions were calibrated on data representing averages for the 1960-70 period, in order to introduce a dynamic feedback loop into the model it was assumed that net migration rates were a linear function of total employment growth rates registered in the previous year. Thus the general form of these functions becomes:

$$NMR(S,E,A,T) = -a + b *CREMP(A,T-1)$$

On theoretical grounds these functions are also valid. The graphic representation of the relationship between the rate of total net migration and the rate of growth of total employment is consistent in its critical values (see Fig. 4.1). In fact the net migration rate is zero when total employment grows at a rate of 3.03%. Since this rate is fairly close to that of vegetative demographic growth, this means that if the economic system provides jobs for the new contingents of population that enter the workforce each year there will be no significant population seeking employment in the other areas, and this situation will not create any incentives for outsiders to migrate to the area.

At lower rates of growth of employment (which means that unemployment of residents will increase), migration rates become negative, that is to say people will begin to leave the region. Finally the marginal rate of migration (with regard to employment) is positive and lower than one, which proves to be perfectly consistent with the theory underlying migration models.

Figure 4.1
NET MIGRATION FUNCTION



The other behavioural equation deals with the long-term va riation of the rural coefficient.

This allows the incorporation into the model of at least two elements, which enhance its conceptual value.

The first of these elements refers to the direction of the intraregional migratory flow, since on determining the values of population, workforce, employment, etc., for the urban sector, by calculating the difference between the total values and those corresponding to the rural sector, it is clear that the availability of human resources in the urban zone is influenced by the situation prevailing in the rural areas.

The second element, which is reflected in the rural coeffi cient and in its long-term variation, is the process of urbanization. The analysis of this process in the context of the formulation of a development plan is important because of the close relationship between the concentrated growth of the urban population, and economic development based on industrialization.

Economic as well as urban literature provides us with some elements for defining a behavioural equation for the rural coefficient. As mentioned in section 1.2.2 the theory of economic sectors holds that the sectoral structure of employment varies with the level of income per capita.Clark's empirical observations show that the proportion of employment in primary sectors decreases as the level of income increases and this is explained by the fact that producti vity and income elasticity of demand for industrial goods and services are higher than those for the primary sectors (see CLARK, 1951; PERLOFF et al., 1960).

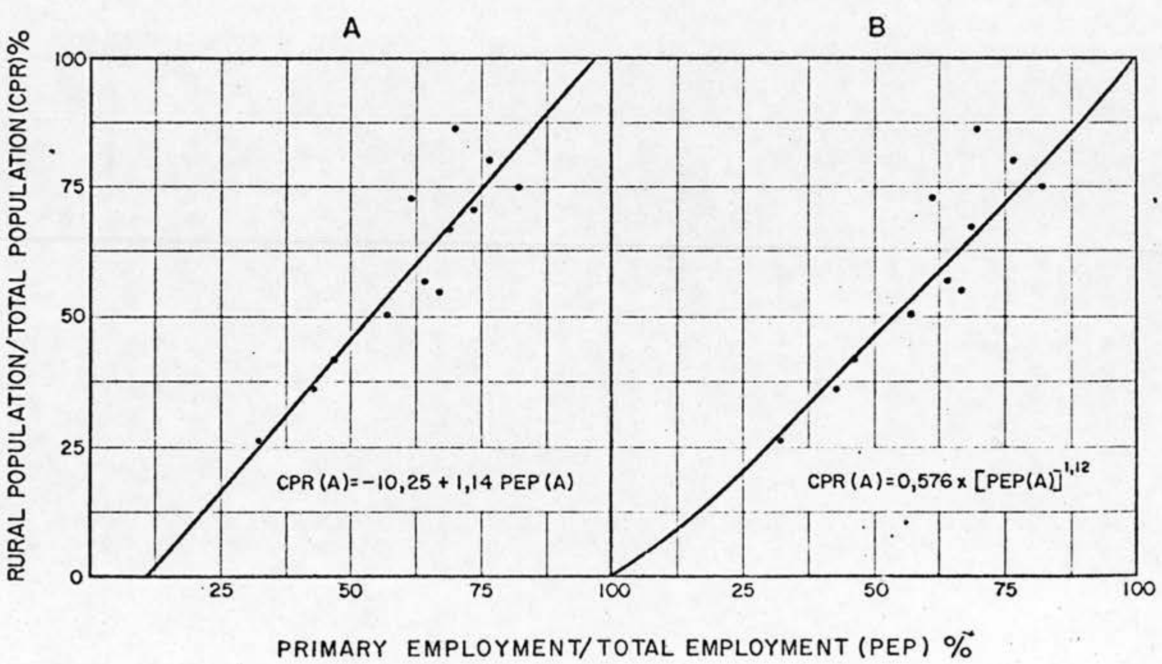
Literature regarding urban development, in its turn, empha sizes that urban growth maintains a direct and strong rela tionship with the development of industry and services, and there is a wide variety of empirical studies confirming such a relationship, (BERRY, 1958; TIEBOUT, 1956; ARTLE, 1962).

On this conceptual basis, the rural coefficient of our model (rural population/total population) was expressed as a function of the proportion of total employment generated by primary sectors (primary sector employment/total employment).

Initially, a linear function was tried and reasonable results were obtained. However, after a deeper analysis it was abandoned because the shape of the functions was in conflict with theoretical considerations. In fact, as shown in Fig. 4.2(A) the linear function does not pass through the origin and cuts the RC axis in its negative segment.

Figure 4.2

RURAL COEFFICIENT FUNCTIONS



At the other extreme it also presents a certain inconsistency, showing more than 100% of rural population when total employment is provided by primary activities. Because of these weaknesses an exponential function passing through the origin and through the point (100, 00) was preferred since it also provided better statistical results (see Fig. 4.2 (B)).

Regression analysis using ordinary least squares (OLSQ) was performed on a double logarithmic version of this function and the following results were obtained:

LCPR(A) = -0.55 + 1.118 * LPEP (A) (*)
(-0.94) (7.83)

LCPR(A) = natural log. of rural coefficient, programme area A

LPEP(A) = natural log. of proportion of total employment generated by primary activities, programme area (A).

$F = 61.35$
$R^2 = 0.83$

Adopting a similar criterion as in the case of net migration functions, a time lag was also introduced in this function. Thus we have

(DEM-17) = CPR(A,T) = 0.576 $*$(PEP (A,T-1)$^{1.12}$

(*) Although the "t" statistic for the intercept may be regarded as rather low, it does not create any conceptual problem, since it indicates that the intercept is not significantly different from zero. This reinforces our assumption that the function has to pass through the origin and this becomes more apparent in equation (DEM-17) where the structure of the function guarantees such a condition.

4.2 EMPLOYMENT SECTOR

This part of the submodel determines the volume and structure of the demand for jobs derived from the amount of labour available in the region and from employment objectives determined exogenously. As such it entails two basic steps: the first consists in determining the availability of human resources in rural and urban areas of the region, while the second establishes the supply of labour.

Once the total population is known, together with its composition as regards sex and age and its potential growth, it is necessary to determine the availability of human resources. This is taken to include the number of people able to work in any fixed period who are fulfilling or could fulfil productive roles, either through their own free will or as a result of changes in the prevailing economic, social and political conditions.

To convert the population totals obtained in the previous section, participation rates are used. "Participation rate" may be defined as the relationship between the workforce and the total population. These rates can be calculated on an overall basis, or for each sex or age group.

The activity rate and thus the workforce is affected as much by demographic as by socio-economic and cultural factors. With regard to the activity rate, it should be noted that sex and age define the active part of the population, from which the workforce is drawn. The elements which condition the demographic factors of population size and age-structure were described above. The incidence of non-demographic factors in the participation rate will now be analysed.

Generally, there is a difference between rural and urban participation rates. In the case of male population in the rural zones, people start work sooner and retire later.

This means that the rate of participation for adult males both in general terms and in the marginal age-groups (under 20 and over 65 years of age) is higher in the rural areas (ELIZAGA, 1965).

The situation is different with the female population. Participation rates for single women are appreciably higher than those for married women, both in general terms and for age-groups and it is usual to find the activity rates decline as the number of children increases. Care of the children and the demands of the home prevent many married women (particularly between the ages of 25 and 35) from applying for paid jobs.

Another factor which influences the level of female activity is connected with the expansion of opportunities which occurs at different levels of urbanization. In a highly urbanized area there is a wider range of economic activities with increased opportunities for women, since there is a greater chance of employment in activities which require this type of labour. Jobs will also be more accessible (in terms of distance), enabling housewives and mothers to get to work. For a detailed assessment of the availability of human resources, different participation rates with regard to sex and the urban/rural situation will be used.

Participation rates can be explained in terms of other variables, but since the formulation of employment policies involves economic as well as non-economic considerations, it is preferable to leave them as a matter of the formulation of objectives. Table 4.5 contains estimates of the participation rates prevailing during the seventies in Brazil. Thus, the employment sector of the model has no behavioural equation, being composed only of eight identities.

TABLE 4.5

BRAZIL: PARTICIPATION RATES BY SEX AND URBAN-RURAL CONDITION - 1970 (PERCENTAGES)

AGE	URBAN		RURAL	
	MALE	FEMALE	MALE	FEMALE
10-14	8	7	34	3
15-19	44	32	82	12
20-24	81	38	90	11
25-29	95	32	88	8
30-39	90	29	95	9
40-49	82	28	96	10
50-59	67	22	96	12
60-69	38	8	92	15
70 and over	20	3	70	8

SOURCE: LEWIN, 1975

Rural and urban labour forces can then be expressed as the addition of the product between the rural and urban populations and the respective participation rate for each strata of active age. For our purposes the limits of active population will be fixed at 15 and 64 years of age. Thus, we have:

$$\text{(EMP-1)} \quad RLF(A,T) = \sum_{S=1}^{2} \sum_{E=4}^{13} POPR(S,E,A,T) * RPR(S,E,T)$$

$$\text{(EMP-2)} \quad ULF(A,T) = \sum_{S=1}^{2} \sum_{E=4}^{13} POPU(S,E,A,T) * UPR(S,E,T)$$

Where

RLF(A,T) = Rural labour force, programme area A

ULF(A,T) = Urban labour force, programme area A

RPR(S,E,T) = Rural participation rate, sex S, cohort E

UPR(S,E,T) = Urban participation rate, sex S, cohort E

Clearly, the total labour force of a given programme area is the addition of rural and urban availability.

$$\text{(EMP-3)} \quad TOTFL(A,T) = RLF(A,T) + ULF(A,T)$$

Once the availability of human resources has been established, the preliminary objectives of employment must be formulated. These are determined by considering the availability of human resources together with certain factors which are included in the general policy of employment and are implicit in the objectives of the development strategy.

The next step deals with the specification of the employment objectives in terms of maximum acceptable rates of unemployment.

The rate of total unemployment consists of the rate of actual unemployment (open unemployment) and that of work done at less than full capacity (underemployment).

Underemployment is taken to be the difference between how much those people who declare some form of unemployment are willing to work and the work they actually do. This is reduced to the concept of the number of unemployed by means of a quotient constituted by what is regarded as a normal working time. It is important to note that underemployment includes both those people who work less than a normal working time and those who do a job which requires less skill than they possess as well as those whose marginal productivity is practically zero.

In order to measure the amount of underemployment, one of the basic aspects to be defined is what is understood by a normal working time. In the model this is taken to be a norm of what must be the work for a whole day, detailing hours per day, days per week and weeks per year (MYRDAL, 1968).

Open unemployment refers to those persons who are able to work and, although actively looking for work, are unable to find any. Thus, total regional rate of unemployment for year T can be expressed as the addition of the maximum acceptable rates of open unemployment and underemployment for that year.

(EMP-4) TUNEM(T) = TOPEN (T) + TUNDE (T)

Being

TUNEM(T) = total unemployment rate, year T

TOPEN(T) = open unemployment rate, year T

TUNDE(T) = underemployment rate, year T

The urbanization process was explained in the demographic sector as a function of the proportion of total employment provided by primary activities. Implicit in this formulation is the idea that the existence of unemployment in rural areas beyond a certain limit will generate a flow of rural-urban migrants, besides the normal one determined by structural, economic and social changes. It follows that for controlling this process great care has to be taken to guarantee a given level of rural employment and it is clear that this matter must be a subject of the formulation of specific objectives.

Thus, we have:

(EMP-5) RTUNE(T) = RUEMP(T) + ROEMP(T)

Where

RTUNE(T) = rural total unemployment rate, year T

ROEMP(T) = rural open unemployment rate, year T

RUEMP(T) = rural underemployment rate, year T

As will be seen in the next chapter, the aggregate supply sector of the economic sub-model is divided into two parts, the rural and the urban. For the reasons presented above, as well as for other reasons of an operational nature, urban unemployment rates are determined as the condition of compatibility between the demand and supply of labour in the composite model.

Thus, this sub-model concludes by determining the demand of jobs (supply of labour) in rural and urban areas, as well as at the regional level.

Total jobs required in the region for satisfying the requirements derived from the availability of human resources and employment goals can be expressed as:

(EMP-6) TJOBR(A,T) = TOTLF(A,T) *(1-TUNEM(T))

By a similar procedure the number of rural jobs required becomes:

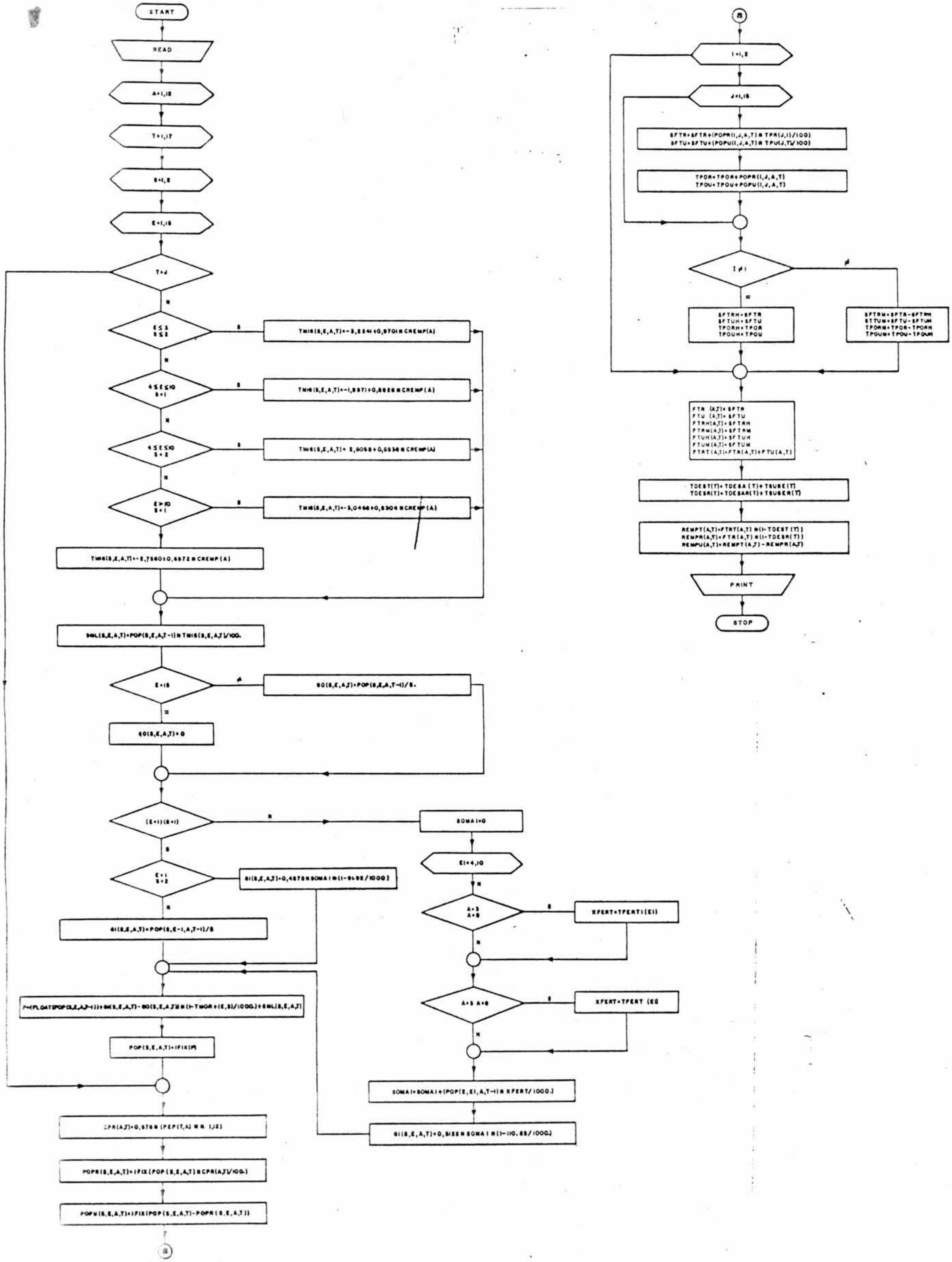
(EMP-7) RJOBR(A,T) = RLF(A,T) * (1-RTUNE (T)).

Finally, the number of urban jobs required is the difference between total regional requirements and rural ones.

(EMP-8) UJOBR(A,T) = TJOBR(A,T) - RJOBR(A,T)

A graphic summary of the demographic and labour supply sub model is presented in the flow chart of the computer programme shown in Fig. 4.3. The details of the computer programme are presented in Appendix I.

FLOW CHART
DEMOGRAPHIC AND EMPLOYMENT SUBMODEL



CHAPTER FIVE

ECONOMIC SUBMODEL

5. ECONOMIC SUBMODEL

This submodel has been designed for predicting the behaviour of the regional economy and for estimating the impact on the region that could result from the implementation of different economic growth policies.

The structure of this part of the model has been strongly conditioned by Brazilian regional policies and the limitations of available statistical information. Thus , it has to be seen as an attempt to harmonize theoretical considerations on regional development with the role the study area is expected to play in the development process of Central-West Brazil and with reliable statistical data.

As explained in section 3.3,this submodel is based on a modified version of the theoretical view of regional development proposed by Siebert (SIEBERT, 1969). However, lack of statistical information and the general orientation of EDIBAP resulting from the conditions of the programme of technical assistance that gave rise to this study made it necessary to introduce some simplifying assumptions to Siebert's original work. Such a theoretical approach to regional development explains the increase of regional output as the final effect induced by two separate groups of factors, namely internal and external determinants. These factors are disaggregated into those affecting the behaviour of aggregate supply and those operating through aggregate demand.

The terms of reference of EDIBAP emphasize that the study must lead to a set of investment projects and specific actions aiming at increasing food production, manufacturing of regional raw materials, supply of energy, etc. This orientation together with the study of the evolution of the regional economy during the last 15 years led to the conclusion that current limiting factor for regional development was aggregate supply. Therefore the economic submodel was designed for explaining the expansion of the supply side of the regional economy.

In order to increase the comprehensiveness of the model a few variables operating through aggregate demand were utilized as independent variables in some behavioural equations. This submodel comprises four major economic sectors. Because of the importance of agriculture and cattle raising in the region these sectors were treated with greater detail. The third sector deals with manufacturing industries and the fourth includes civil construction, commerce and services and government.

For ease of explanation this chapter is divided in four sections devoted to the description of the sectorial components of the regional economy. They also explain the econometric work done for calibrating the submodel.

5.1 AGRICULTURE

Agriculture is highly dependent on natural conditions like climate, quality of soil, availability of water, etc. Because of the tropical climate of the study area, its altitude and its rather poor soil conditions, potential land for agriculture is a relatively small part of its geographical area (8.8%). Of the rest 59.4% is ecologically recommended for cattle-related activities and 21.4% is to be devoted to forestry. In spite of these limitations agriculture has, nowadays, a great potential for growth, since in 1978 only 22% of available land for cropping was utilized for that purpose. This means that Mato Grosso and Mato Grosso do Sul can increase nearly fivefold the volume of their agriculture before coming up against any ecological constraints.

Natural conditions of the Region, together with its location with regard to the national markets and the way in which the region has been integrated into the Brazilian economy, explain why its agriculture should be mainly devoted to annual crops, rice being by far the most important individual crop (64.8% of the total cultivated area in 1978. See table 5.1). This highly specialized pattern of crops allowed us to follow a simplified procedure when modelling the behaviour of this sector. Four different crops were defined. Rice and soya beans were taken as one crop since their production is characterized by relatively similar yields, labour requirements and production practices. Although the total production of coffee and sugar cane in the area is very small (less than 2% of the total cultivated area), they were taken as separate crops. The reason for this decision is that both crops are traditional Brazilian export products and are controlled by separate agencies (IBC and IAA - Brazilian Coffee Institute and Sugar and Alcohol Institute) which define their own policies and possess specific financial mechanisms. Besides these particularities coffee and sugar cane are destined to play a major role in the agricultural development of the region both by increasing regional exports and because the area is expected to make an important contribution to the national programme of petroleum substitution.

The fourth identified crop is a mixture of many products that characterize subsistence farming (mainly corn, beans, cotton, etc). Although these simplifying assumptions may induce some estimation and forecasting errors, they seem reasonable in view of the high representativity of the crops chosen. Moreover the selection of a crop that accounts for nearly 80% of the cultivated area made possible a more thorough treatment of the factors that influence their behaviour, since serious agricultural and economic studies were available for these regional products.

TABLE 5.1

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

LAND DEVOTED TO CROPS

(HECTARES)

YEAR	RICE	SOYA BEANS	COFFEE	SUGAR CANE	OTHER CROPS	TOTAL
1965	312,495	804	22,524	13,817	263,157	612,797
1966	252,501	1,465	23,077	15,445	266,353	558,841
1967	220,566	2,322	16,996	15,338	257,933	513,205
1968	108,383	2,491	12,746	10,879	256,556	491,055
1969	251,217	2,660	10,158	11,457	304,369	579,879
1970	321,309	5,809	10,176	11,039	324,394	672,727
1971	318,750	13,320	10,677	10,994	353,149	706,890
1972	391,777	21,737	11,627	12,520	410,814	848,475
1973	472,116	86,359	13,481	13,425	435,562	1,020,943
1974	503,054	151,398	20,948	13,141	466,166	1,154,743
1975	772,995	194,280	21,179	11,490	523,657	1,523,601
1976	1,493,261	191,114		9,839	547,563	2,241,777
1977	1,546,663	412,122		10,497	556,786	2,526,068
1978	1,547,158	470,753		10,126	358,389	2,386,426

SOURCE: Anuários Estatísticos de Mato Grosso (Statistical Yearbooks of Mato Grosso)

5.1.1 General Considerations

Underlying the agricultural submodel there is a basic premise which requires some comments. It concerns the way in which land, product and employment are related for a particular crop and can be explained as follows.

The output obtained from a crop is a function of the fertility of the land, which in its turn depends on soil conditions, quality of inputs utilized (breeds, fertilizers, pesticides, etc) and also on climate. Soil conditions and climate are given and, in normal situations, they have to be regarded as fixed or exogenous for policy formulation purposes. Thus, the management of the quality of inputs become the only available way to increase land productivity.

Land productivity being thus dependent on factors that regulate fertility and vegetal cycles, it is quite risky to determine the labour requirements for agriculture by means of the labour productivity concept. In fact natural factors such as the amount of rainfall are likely to affect yields and production to a great extent without bringing about any changes in the manpower required for carrying out the activities involved in the productive process.

Thus, it is necessary to use a land-labour ratio in order to avoid the afore mentioned difficulties. This ratio is related to the physical productivity of labour under certain conditions. For a given crop the land-labour ratio equals the inverse (reciprocal) of physical labour productivity if both the input mix and the factors affecting fertility remain constant.

The land-labour ratio represents the manpower required for cultivating one unit of land. As such it is inversely related to the degree of mechanization of agricultural activities.

It follows that no relationship is recognized between aggregated agricultural output and mechanization, unless a shortage of labour is a limiting factor.

In accordance with this approach it is found that the amount of land allocated to crops is the basic element that determines both agricultural output and employment. Thus, in building the model special care was taken to give an explicit treatment to those variables considered by farmers in their land allocation decisions.

As is usual in economics, any attempt to derive a supply function starts from the assumption that entrepreneurs (farmers in our case) try to maximize profits. Since land available for crops and technology are fixed for individual farmers in the short run, the only variable left under a farmer's control is the amount of land to be allocated to each crop. It follows that profits will be a direct function of the behaviour of prices and highly dependent on land allocation decisions. Obviously these decisions are greatly influenced by the past behaviour of prices.

Since farmers do not know the exact price they will receive for their future production at the time when they have to decide the amount of land to be allocated to each crop, this decision is adopted on the basis of certain assumptions about the future behaviour of agricultural prices. Such assumptions, usually called "expected normal prices" have been widely studied and formalized into lagged linear models (NERLOVE, 1958; COX, 1975).

Nerlove applied this concept for the specification of agricultural supply functions. He expressed the amount of land a farmer allocates to a given crop as a linear function of the "expected normal price" and a random disturbance:

(i) $Y(t) = a+b\,P^*(t)+E(t)$

Where:

$Y(t)$ = land devoted to a given crop, year t.

$P^*(t)$ = expected normal price, year t.

$E(t)$ = error term

a,b = parameters

He also assumed that farmers adjust the expected normal price each year in proportion to the discrepancy between the observed price and the expected normal price in the previous year.

(ii) $P^*(t) - P^*(t-1) = B\,(P(t-1) - P^*(t-1))$, or

$$P^*(t) = P^*(t-1) + B\,(P(t-1) - P^*(t-1))$$

Where: $0 \leqslant B \leqslant 1$

and $P^*(T-1)$ = expected normal price, year t-1

$P\,(t-1)$ = observed market price, year t-1

B = expectancy variation coefficient

By means of some algebraic manipulations the expected normal price can be expressed as a linear function of a series of past observed prices (*). Thus we can write:

(iii) $P^*(t) = BP(t-1) + B(1-B)\,P(t-2) + B(1-B)^2 P(t-3) + ..$

(*) The mathematical procedure can be described as follows:

$$P^*(t) = (1-B)P^*(t-1) + BP(t-1)$$

$$P^*(t-1) = (1-B)P^*(t-2) + BP(t-2)$$

$$P^*(t-2) = (1-B)P^*(t-3) + BP(t-3)$$

After some reordering we have

$$P^*(t) = BP(t-1) + B(1-B)\,P(t-2) + B(1-B)^2\,P(t-3) + ..$$

$$+ B(1-B)^{n-1}\,P(t-n) + (1-B)^n\,P^*(t-n)$$

since $0 \leqslant B \leqslant 1$, if $n \rightarrow 00$; $(1-B)^n \rightarrow 0$ and obviously the term $(1-B)^n P^*t-n$ will tend to zero.

Substituting equation (iii) for P^*t in equation (i) the following supply function is obtained.

$$\text{(iv)}\quad Y(t)=a+b\left[BP(t-1)+B(1-B)P(t-2)+B(1-B)^2P(t-3)+\ ..\right] + E(t)$$

Applying the Koyck transformation (See THEIL, 1971) to this equation a very simple supply function arises:

$$\text{(v)}\quad Y(t)=aB+bBP(t-1)+(1-B)Y(t-1)+\left[E(t)-(1-B)E(t-1)\right]$$

This supply function explains the amount of land allocated to a particular crop as a linear function of the market price observed the previous year, the area cultivated that year and a random disturbance. It can be easily quantified by using regression analysis if time series data are available, although some problems of serial correlation in the error term may arise. In order to avoid this problem the BOX and JENKINS iterative technique was used when calibrating the model.

5.1.2 The Agricultural Sector of the Model

As mentioned above, agriculture in the study area has shown high growth rates during the last decade. Since there is still a huge potential for further expansion of the cultivated area, the agricultural sector of the model starts by defining a behavioural function for explaining this expansion of the agricultural frontier. From the studies developed by EDIBAP it was possible to deduce that land devoted to crops and pasture grows as a function of the expansion of the road network and also of the behaviour of the amount of loans granted for agriculture and cattle raising.

The rational use of natural resources, in its turn, imposes a limit to the amount of land to be devoted to these activities. Thus, utilized land cannot be greater than the area ecologically recommended for crops and pasture . Such an ecological limit is determined in the physical and environmental submodel.

This behavioural function was quantified by means of ordinary least squares (OLSQ) on time series data (see table 5.2) and the following results were obtained:

$$\text{(AGR-1)}\quad SAPP(T) = -\underset{(-2.76)}{4991159} + \underset{(5.86)}{603.5}*REDV(T) + \underset{(4.77)}{65.65}*CRAP(T) \leqslant POTAPP$$

Where

SAPP(T) = total land devoted to crops and pastures, year T

REDV(T) = Road network in the states of Mato Grosso and Mato Grosso do Sul, year T

CRAP(T) = Amount of credit granted for agriculture and cattle raising, both states, Year T (millions of constant cruzeiros)

POTAPP = Ecological limit for agriculture and pasture

R^2 = 0.99

F = 582

The contribution of each programme-area to this land allocation is determined by means of a coefficient indicating the level of utilization of each area's territory. Such a level of utilization should be proportional to the population and to the road network of each programme-area. Land devoted to crops and pasture at this subregional level is also constrained by an ecological limit. OLSQ performed on cross - section data produced the following results:

TABLE 5.2

STATES OF MATO GROSSO AND MATO GROSSO DO SUL. DATA UTILIZED FOR QUANTIFYING THE AGRICULTURAL FRONTIER FUNCTION

YEAR	LAND DEVOTED TO CROPS AND PASTURES (HA)	FEDERAL AND STATE ROAD NETWORK (KM)	TOTAL LOANS GRANTED FOR AGRIC.& CATTLE-RAISING(*)
1969	4,820,531	15,674	2,275.0
1970	5,368,417	16,548	3,059.0
1971	5,901,036	17,724	3,936.3
1972	6,598,748	18,468	6,944.5
1973	7,388,187	19,484	9,961.4
1974	8,196,802	20,455	12,624.3
1975	9,335,698	20,988	24,511.3
1976	10,886,251	21,911	38,458.6
1977	12,098,277	23,140	38,265.9
1978	12,986,991	24,224	51,649.4

SOURCE: Anuários Estatísticos de Mato Grosso (Statistical Yearbooks of Mato Grosso)

DNER (1979) and BANCO CENTRAL DO BRASIL (Central Bank of Brasil) 1979

(*) Million Cruzeiros of April, 1980.

(AGR-2) $CDIST(A,T)=2.508 + 1.415*10^{-5}*POP(A,T-1)+0.001979+ REDV(A,T)$

(-1.40) (1.17) (3.42)

CDIST(A,T)=% of crops and pasture, programme-area A, year T.

POP(A,T) = total population, programme-area A, year T

REDV(A,T) = Road network, programme-area A, year T

R^2 = 0.85

F =24.83

Consequently,

(AGR-3) $SAPP(A,T) = SAPP(T)*CDIST(A,T) \leqslant POTAPP(A)$

Where

SAPP(A,T)=Land devoted to crops and pasture, programme-area A, year T

POTAPP(A)=Ecological limit for agriculture and pasture, programme-area A

Once the amount of land to be utilized in agriculture and intensive cattle raising has been defined, the land for each one of the crops selected should be determined. In so doing special care was taken to make an accurate quantification of the supply function of rice (including soya beans) because of its great importance for regional agriculture. In order to minimize forecasting errors a single supply function was defined for the whole area and was later disaggregated at the subregional level. (*)

(*) If estimates are made for each programme-area, the error in the overall estimation may become too big. This is due to the fact that, on the one hand, subregional regressions produced larger errors than the overall estimation, and on the other, that such errors are added in when calculating the total area devoted to rice and soya.

Thus, the total land devoted to rice and soya beans was defined as a function of the land utilized in the previous year, observed market price in year T-1 and the amount of credit granted for agriculture in the current year. (*) For quantifying such a function, OLSQ on time series data was used (see table 5.3).

(AGR-4) HA(1,T)=-453390+0.789*HA(1,T-1)+1465.7*PREC(1,T-1)
(-1.61) (2.25) (2.90)
+12.73*CRAG(T)
(1.85)

HA(1,T) = land devoted to rice and soya, both states, year T.
PREC(1,T-1) = price of rice, year T-1
CRAG(T) = total credit granted for agriculture, both states, year T
R^2 = 0.98
F = 91.25
D.W. = 2.01

As expected, this function provided a significant statistical fit but presented problems of serial correlation in the error term (D.W=2.01). Autoregression in this type of function is a serious problem since the equation has a lagged dependent variable on its right hand side. Because of this the traditional Durbin-Watson test proves to be unsatisfactory and a special test developed by J. Durbin (DURBIN, 1970) is recommended. Unfortunately this new test only provides reliable detection of serial correlation for big samples, so a more laborious procedure had to be adopted. The BOX and JENKINS method is an iterative technique that eliminates serial correlation in two stages: the first identifies an autoregressive model by processing the residues

(*) Initially prices for both products were included in the function but regression analysis led to inconsistent results. Thus, as this type of function refers to a single product, the price of rice was adopted as representative for the whole set.

TABLE 5.3

STATES OF MATO GROSSO AND MATO GROSSO DO SUL. DATA UTILIZED FOR QUANTIFYING THE RICE AND SOYA BEANS FUNCTION

YEAR	LAND DEVOTED TO RICE AND SOYA (HA)	MARKET PRICE OF RICE (*)	TOTAL LOANS GRANTED FOR AGRICULTURE (**)
1965	312,495	-	-
1966	252,501	380.85	-
1967	220,566	419.35	-
1968	208,383	432.20	-
1969	251,217	375.00	409.57
1970	327,118	330.16	526.08
1971	332,070	439.50	717.13
1972	413,514	471.80	1,957.51
1973	558,475	469.08	2,272.62
1974	654,452	387.15	3,777.61
1975	967,275	698.36	11,561.26
1976	1,684,375	411.94	24,156.81
1977	1,958,785	373.54	28,335.89
1978	2,017,911	488.58	41,468.73

SOURCE: Anuários Estatísticos de Mato Grosso (Statistical Yearbooks of Mato Grosso); CFP, 1980; Banco Central do Brasil (Central Bank of Brazil), 1979

(*) Price per 60 kg of rice, expressed in currency of April 1980.

(**) Million cruzeiros of April 1980

of the original regression; the second is devoted to the estimation of the autoregressive model identified in stage one. In our case the identification procedure led to a function with variables lagged for two periods, which provided satisfactory results.

(AGR-4*) HA(1,T) = -454,489 + 0.988*HA(1,T-1)-0.536*HA(1,T-2)
+1,465.7*PREC(1,T-1)+113.8*PREC(1,T-2)
+12.73*CRAG(T)+9.8*CRAG(T-1)

To estimate the amount of land devoted to rice and soya in each programme area a quite complex procedure was adopted. Firstly, supply functions for each subregion were estimated by OLSQ (see table 5.4). Secondly, a coefficient representing the contribution of each programme-area to this new total was calculated. Finally these coefficients were applied to the land devoted to rice and soya thoroughout the region (equation AGR-4*). In this way we have:

(AGR-5) HHA(1,A,T)=a+b*HHA(1,A,T-1)+c*PREC(1,T-1)+d*CRAG(T)

Where

HHA(1,A,T)= land devoted to rice and soya, programme area A, year T (auxiliary variable). Regression coefficients of this family of equations are presented in table 5.6.

(AGR-6) $PHHA(1,A,T) = HHA(1,A,T) / \sum_{A=1}^{12} HHA(1,A,T)$

PHHA(1,A,T) = % of land devoted to rice and soya, programme-area A, year T

(AGR-7) HA(1,A,T) = PHHA(1,A,T)*HA(1,T)

HA(1,A,T) = Actual land devoted to rice and soya, programme-area A, year T

Land devoted to coffee and sugar-cane is determined exogenously. This procedure was judged to be the most suitable

TABLE 5.4

SUBREGIONAL FUNCTIONS FOR RICE AND SOYA BEANS

PROGRAMME AREA	INTERCEPT	LAND DEVOTED TO RICE AND SOYA (YEAR T-1) HA(1,T-1)	PRICE OF RICE (YEAR T-1) PREC(1,T-1)	LOANS GRANTED TO AGRICULTURE CRAG (T)	F	R^2
1) ALTO PARAGUAY	-12,772.26 (-1.29)	0.47 (1.80)	60.38 (3.32)	0.43 (1.40)	27.83	0.93
2) CACERES	-13,604.60 (-1.08)	0.46 (1.74)	72.15 (3.13)	0.47 (1.29)	21.33	0.91
3) CUIABA	-20,696.86 (-1.93)	0.49 (1.89)	75.96 (3.93)	0.71 (1.81)	58.47	0.97
4) RONDONOPOLIS	-14,768.66 (-0.53)	0.34 (1.25)	133.43 (3.21)	0.76 (1.26)	14.81	0.88
5) BARRA DO GARÇAS	-18,420.05 (-1.94)	0.53 (1.92)	65.06 (3.61)	0.67 (1.66)	63.20	0.97
6) DIAMANTINO	-13,666.53 (-4.16)	1.12 (17.80)	36.07 (4.87)	-	176.64	0.98
7) ALTO TAQUARI	-21,347.53 (-1.72)	0.50 (1.79)	157.86 (3.58)	1.52 (1.63)	50.63	0.96
8) CAMPO GRANDE	-67,594.19 (-1.73)	0.50 (1.76)	241.60 (3.29)	3.41 (1.92)	81.61	0.98
9) BODOQUENA	-18,816.14 (-2.33)	-0.97 (-7.75)	78.51 (4.23)	2.41 (15.24)	87.63	0.97
10) CORUMBA	-445.01 (-0.63)	0.40 (1.67)	3.53 (3.64)	0.01 (1.47)	13.14	0.87
11) TRES LAGOAS	-34,802.95 (-1.69)	0.48 (1.71)	133.38 (3.59)	1.34 (1.68)	51.88	0.96
12) DOURADOS	-179,506.78 (-2.12)	1.20 (18.87)	484.39 (2.52)	-	187.53	0.98

N.B. Values in brackets correspond to the "t" statistics (student test) one for the purpose of increasing the flexibility of the model for representing the policies that IBC and IAA may define. The low incidence of both crops in regional agriculture and the considerable dependence of their production on official policies justify this simplified treatment. Thus we can write:

(AGR-8) $HA(2,A,T) = \overline{HA}(2,A,T)$

(AGR-9) $HA(3,A,T) = \overline{HA}(3,A,T)$

Where

$\overline{HA}(2,A,T)$ = land devoted to coffee, programme-area A, year T

$\overline{HA}(3,A,T)$ = land devoted to sugar-cane, programme area A, year T

In the case of the supply function for other products (fourth selected crop) an erratic pattern of behaviour was observed with regard to past market prices. This is explained mainly by the fact that this crop includes several products, which makes it difficult to define a price representative of all of them. It is also due to the fact that, to a great extent, this crop represents subsistence farming which does not necessarily follow market laws. In confirmation of this statement a negative elasticity of this supply function was found with regard to the amount of credit for normal agricultural expenses (excluding credit for investment) (*).

(*) The relation between land devoted to subsistence crops and bank credit is:

$$HA(4,T) = \underset{(1.77)}{-85086} + \underset{(4.48)}{1.401} * HA(4,T-1) - \underset{(-2.88)}{10.48} * CRCA(T)$$

Where

HA(4,T) = land devoted to subsistence crops, year T.
CRCA(T) = amount of credit granted for normal agricultural expenses, year T.
R^2 = 0.77
F = 11.94

This means that to the extent that financial resources for agriculture increase, the proportion of subsistence crops decreases, since a greater amount of land is devoted to a market agriculture.

For this reason and after some empirical studies a new type of supply function was adopted that explains the amount of land allocated to this crop in terms of the rural population of each programme-area. It was quantified by means of OLSQ on cross-section data (see Fig. 5.1).

(AGR-10) HA(4,A,T)= 8,395+0.4057 POPR (A,T-1)

(1.01) (5.54)

HA(4,A,T)= land devoted to other crops, programme area A, year T

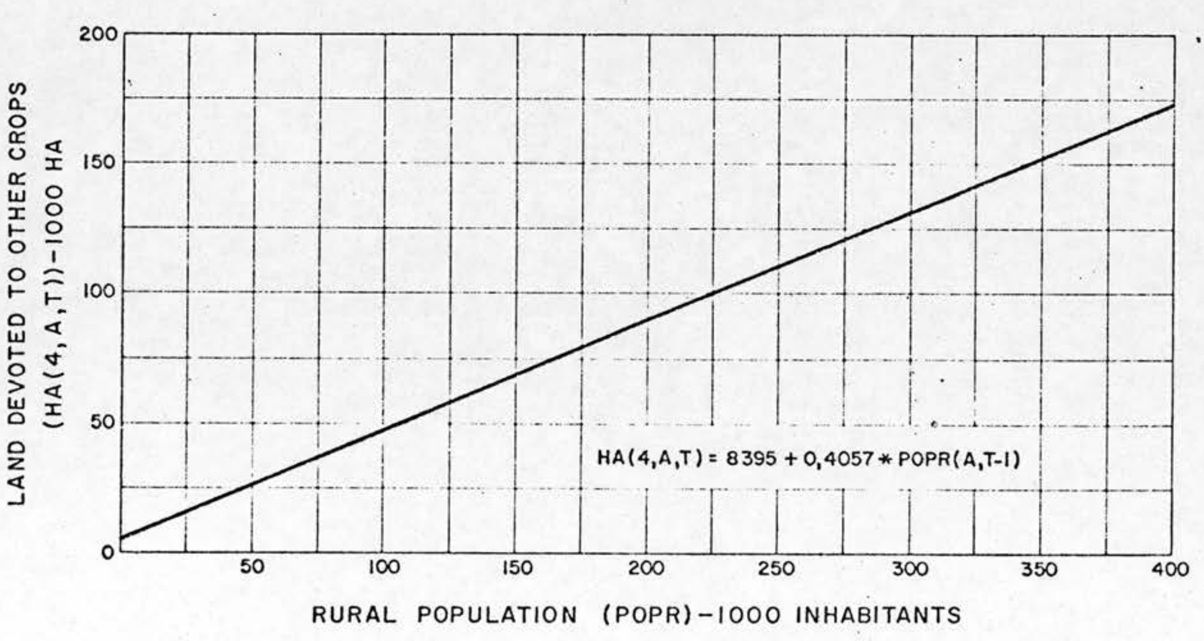
POPR(A,T)= rural population, programme-area A, year T

R^2 = 0.75

F = 30.74

Figure 5.1

EXPLANATORY FUNCTION OF THE LAND DEVOTED TO OTHER CROPS



Total cultivated land in each programme-area is obtained by summing the land allocated to each crop. Land devoted to pasture is the difference between total cultivated land and that resulting from equation AGR-3

$$\text{(AGR-11)} \quad HA(A,T) = \sum_{C=1}^{4} HA(C,A,T)$$

$$\text{(AGR-12)} \quad SPP(A,T) = SAPP(A,T) - HA(A,T)$$

HA(A,T) = total cultivated land, programme-area A, year T

SPP(A,T) = land devoted to pasture , programme-area A, year T

Once the use of productive land has been defined the next step deals with the quantification of the level of production and employment. As previously explained physical land productivity depends on soil conditions, quality of inputs and also on climate. For policy purposes climate and soil conditions have to be regarded as fixed; thus land productivity is to be expressed as a function of the input mix (breeds, fertilizers, pesticides, etc). The quality of inputs actually utilized by farmers depends on their technical knowledge, their attitude towards innovation and obviously on the relative cost of the inputs. Due to the dependence of the input mix on technical, economic and even socio-cultural factors, it is not possible to expect significant changes in the productivity of land within a short period of time.

Although these comments suggest that land productivity is likely to present great stability, the explosive growth of the agricultural frontier in the region under study is to be seen as a factor that may lead to significant modifications of this technological parameter.

In fact, in a process of expanding the agricultural frontier that entails the incorporation of more than 250,000 hectares each year there exists the possibility of incorporating highly productive lands or cultivating land unsuitable for cropping. Because of the quantitative incidence of the area incorporated each year into the total cultivated land, any significant difference between marginal and average productivity is likely to produce alterations in average productivity more marked than those derived from modifications to the input mix. For this reason it was judged rather risky to define a function for explaining land productivity in terms of the quality of the input mix or of input costs. Thus, for purposes of simplicity, it was decided to leave this variable for exogenous determination.

In this way the physical production of each programme-area is obtained by multiplying the amount of land devoted to each crop by its respective physical productivity. The value of production results from applying market prices to the physical production.

(AGR-13) $PRFAG(C,A,T) = HA(C,A,T)*PF(C)$

(AGR-14) $VBPAG(A,T) = \sum_{c=1}^{4} PRFAG(C,A,T)*PREC(C,T)$

PRFAG(C,A,T) = Physical production, crop C, programme-area A, year T

PF(C) = Physical productivity, crop C

VBPAG(A,T) = Value of agricultural production, programme-area A, year T

PREC(C,T) = Market price, product C, year T

For determining the employment generated by agriculture it was assumed that the process of mechanization mainly affects the production of rice and soya beans with only a small impact on the other crops. In fact, the production of coffee and sugar cane has achieved an almost standard technology which has been introduced by means of an intensive technical assistance programme to farmers. Since financial aid granted by official agencies for coffee and sugar cane is subject to the approval of the government body in charge of technical assistance it is reasonable to assume that there will be no significant difference in labour requirements among programme-areas.

In the case of other crops the situation is different because their production is carried out by a great number of small farmers. The level of mechanization on this type of farm is very low and this is explained by the scarcity of capital and also because it is not profitable to introduce machinery into small and highly diversified holdings. Thus it was assumed that labour requirements for these crops will remain constant throughout the region in the near future.

After some empirical analysis it was established that the production of rice and soya beans was mechanized wherever there was one tractor per 120 hectares of crops or less, and the production of these crops was considered as manual where there was one tractor per 500 hectares or more (*). For intermediate situations a proportion between both technologies was defined, as shown in table 5.5.

Labour requirements per hectare for each crop were determined by means of the coefficients shown in table 5.6 and were then transformed into permanent and temporary jobs by applying the median to the monthly series. The median was utilized because it is the central tendency statistic that minimizes deviations in absolute terms. Thus we have:

(*) Although the presence of a tractor does not guarantee that harvesting and other activities are carried out by means of mechanized procedures, this assumption was adopted after ascertaining that in the study area the use of agricultural machinery (harvesters) shows a high correlation with the number of tractors. Using OLSQ on cross section data the following function was obtained:

$$\underset{(-3.02)}{HARV = -85.19} + \underset{(2.51)}{0.26 * TRACT}$$

HARV = number of automatic harvesters; TRACT=number of tractors

$R^2 = 0.98$ $\quad$ $F = 57.23$

TABLE 5.5

RICE AND SOYA BEAN CROPS. RELATIONSHIP BETWEEN AVAILABILITY OF TRACTORS AND TECHNOLOGY UTILIZED

HECTARES PER TRACTOR	% MANUAL CROP	% MECHANIZED CROP
500 and over	100	-
200 to 499	80	20
121 to 199	50	50
120 or less	20	80

TABLE 5.6

MONTHLY LABOUR REQUIREMENTS PER HECTARE OF CROPS (MAN/DAYS)

MONTH	RICE-SOYA BEANS		OTHER CROPS	COFFEE	SUGAR CANE
	MANUAL	MECHANIZED			
JAN	2.43	0.24	2.20	4.16	3.24
FEB	4.36	0.42	2.99	4.16	3.23
MAR	6.04	0.60	3.83	4.16	1.58
APR	3.74	0.31	2.58	4.16	0.95
MAY	0.30	0.04	5.30	0.00	8.65
JUN	0.30	0.04	4.64	1.24	8.65
JUL	0.30	0.04	0.16	21.12	8.67
AUG	0.80	0.10	0.36	21.12	8.37
SEP	0.80	0.10	0.76	10.76	8.37
OCT	1.90	0.20	1.95	4.12	8.58
NOV	4.20	0.32	1.42	5.24	0.25
DEC	4.53	0.25	0.88	3.72	1.97

SOURCE: EDIBAP

$$\text{(AGR-15)}\quad EMPAG\ (1,A,M,T) = HA(1,A,T) * \alpha * [RMOA(M) + (1- \ ) * RMOB(M)]$$

$$\text{(AGR-16)}\quad EMPAG\ (C,A,M,T) = HA(C,A,T) * RMO(C,M)$$

$$C = 2,3,4$$

$$\text{(AGR-17)}\quad EMPA(A,M,T) = \sum_{c=1}^{4} EMPAG\ (C,A,M,T)/22$$

$$\text{(AGR-18)}\quad EMPAP(A,T) = MEDIAN(EMPA(A,M,T))$$

$$\text{(AGR-19)}\quad EMPAT(A,T) = \sum_{M=1}^{12} (EMPA(A,M,T) - EMPAP(A,T)/12$$

Where:

EMPAG(C,A,T) = labour requirements, crop C , programme-area A, month M, year T (expressed in man days)

RMOA(M) = labour requirements per hectare, rice and soya bean crops, manual crop, month M

RMOB(M) = labour requirements per hectare, rice and soya bean crops, mechanized crop, month M

α = coefficient for combining manual and me chanized technologies (derived from table 5)

RMO(C,M) = labour requirements per hectare , crop C , month M

EMPA(A,M,T) = agricultural employment, programme-area A, month M, year T (expressed in man-months)

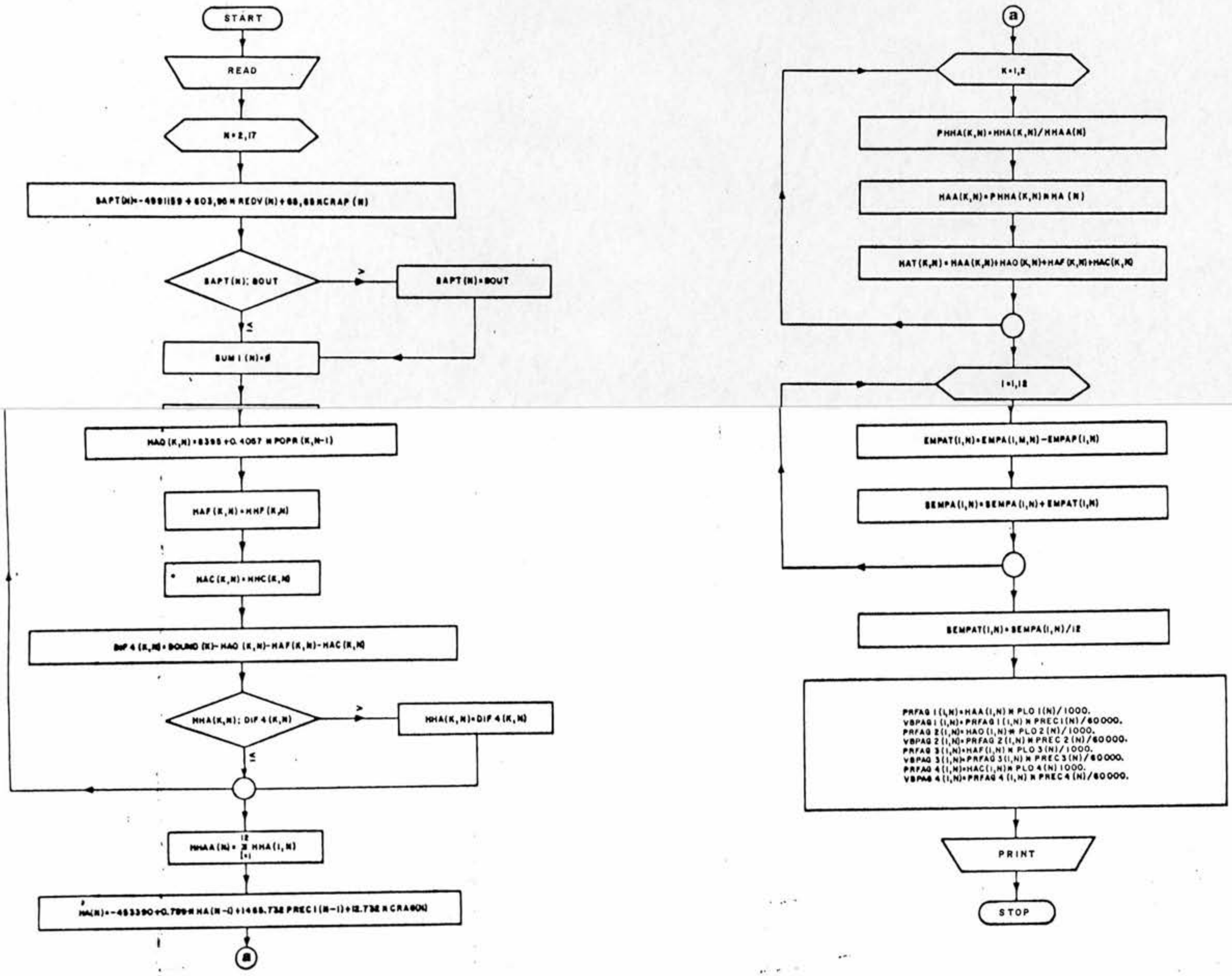
EMPAP(A,T) = permanent agricultural employment, program me-area A, year T

EMPAT(A,T) = temporary agricultural employment, program me-area A, year T (Sum of positive devia tions. Expressed in terms of equivalent full employment).

Finally, a synoptic view of the structure of the agricultural sector of the model is provided by the flow-chart of the com puter programme shown in Fig. 5.2.

Figure 5.2

Flow Chart
Economic Submodel-Agricultural Sector



5.2 CATTLE RAISING

Cattle related activities represent one of the most important and dynamic sectors in the study area. Although this sector grew at a rate of 17.9% per year during the sixties, it still presents a characteristic of low technological levels. As a result it is possible to foresee that cattle raising has ample scope for increasing its level of activity without adversely affecting the growth potential of agriculture. In fact, available land with the potential for this activity may support herds of cattle more than three times greater than that existing in 1980, even without considering any technological improvement (see Table 5.7).

Cattle raising in the states of Mato Grosso and Mato Grosso do Sul is mainly devoted to beef production, although there is some dairy farming near the state capitals of Cuiabá and Campo Grande and in the south. Because of the small incidence of dairy farming on a commercial scale throughout the area, this activity is regarded, as far as the model is concerned, as a by-product of beef production. Thus no allowance is made for explaining the behaviour and particularities of milk production.

If viewed from an economic standpoint the stock of cattle seems to be a particular type of asset. It can be regarded as a capital asset that produces milk, calves and meat. It can also be seen as a finished product for consumption (meat). Due to the dual role that cattle herds play in the economic behaviour of this activity, the explanation of the evolution of the cattle stock becomes the central element of this sector of the model. Once the volume and structure of the cattle stock have been established it is possible to determine the product and employment generated each year by this activity.

TABLE 5.7

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
EVOLUTION OF CATTLE STOCK AND POTENTIAL STOCK

PROGRAMME AREAS	HEAD OF CATTLE (1000 ANIMALS) 1960	1970	1975	1980*	POTENTIAL STOCK * (1000 Animals
1) ALTO PARAGUAY	13	81	317	479	1,219
2) CÁCERES	217	270	347	532	2,504
3) CUIABÁ	1,029	745	885	1,010	3,240
4) RONDONÓPOLIS	202	460	697	1,370	2,543
5) BARRA DO GARÇAS	125	298	632	1,227	5,819
6) DIAMANTINO	19	90	233	509	19,136
STATE OF MATO GROSSO	1,605	1,944	3,111	5,127	34,461
7) ALTO TAQUARI	419	534	656	882	2,039
8) CAMPO GRANDE	517	552	764	1,026	3,121
9) BODOQUENA	500	974	1,155	1,548	2,649
10) CORUMBÁ	1,444	3,008	2,485	2,688	3,027
11) TRÊS LAGOAS	497	781	1,157	2,006	6,528
12) DOURADOS	671	1,637	2,654	3,994	6,316
STATE OF MATO GROSSO DO SUL	4,048	7,486	8,871	12,144	23,683
UPPER PARAGUAY RIVER BASIN	5,653	9,430	11,982	17,271	58,144

SOURCE : FIBGE, Agricultural Censuses
* : Estimates of EDIBAP .

At the microeconomic level potential herd size is limited by the size of the farm, its technological level (cattle-land ratio) and also by available capital. Actual herd size, for its part, depends on the level of use the farmer makes of available resources which in the final analysis will be a function of the expected rate of return of cattle raising as compared with those rates of return associated with alternative land uses.

A farmer can increase the size of his herd by buying cattle in the market, reproducing from his own herd or in both these ways. Conversely, he can reduce his herd by selling cattle to other farmers or slaughter-houses. At the regional or national levels, however, increasing the cattle stock becomes basically an endogenous and gradual process which takes a certain period of time. (*)

Since meat consumption tends to follow a similar pattern of behaviour to that of population (no change in the distribution of income is assumed) and as reproduction is regulated by strict biological laws that require definite periods of time, under normal market conditions big changes in the size and composition of the regional cattle stock can not be expected in the short term. Thus, it is possible to conclude that aggregated behaviour of the cattle stock is likely to follow medium term fluctuations of profit expectations rather than short-term ones. Assuming as constant the elements that determine the cost function of this activity, it is found that its expected rate of return depends on the farmer's expectation concerning the future behaviour of beef prices. Thus farmers, trying to maximize profits, basically manipulate the rates of extraction and reproduction, thereby affecting the volume and structure of their herds.

(*) This is due to the fact that at these scales (national and regional) normal cattle transactions consolidate among them without affecting the size of the cattle stock.

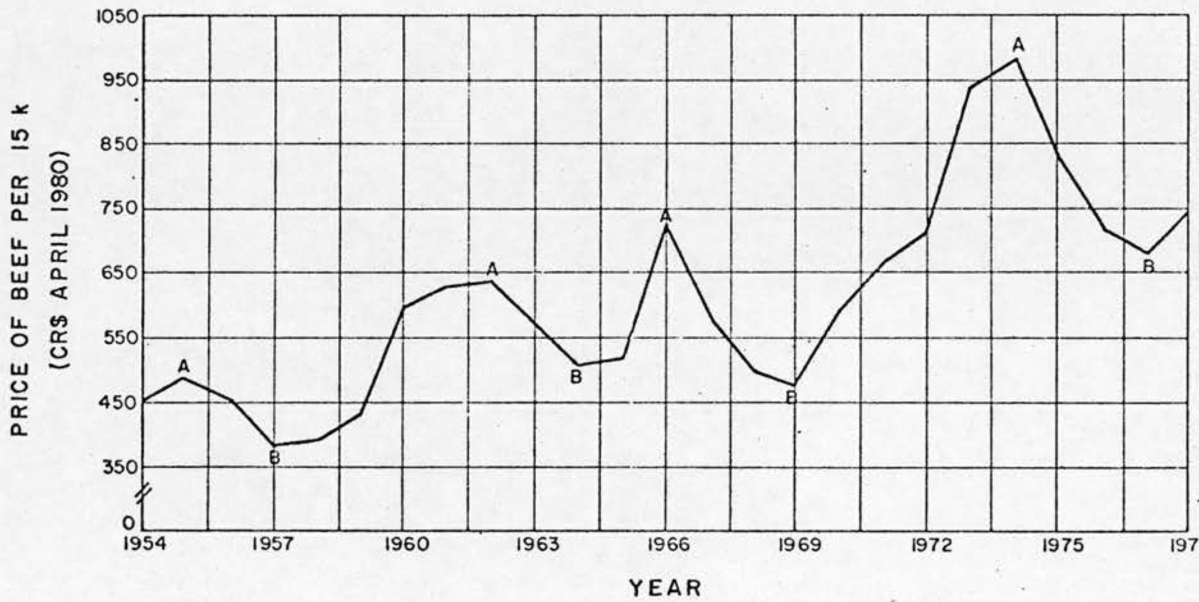
The historical relationship between the rates of growth of the cattle stock and beef prices has defined a particular type of behaviour known as the "cattle cycle".

Let us take a brief look at the main features of the cattle cycle, summarising the findings of a recent study carried out for the state of Goias in Central-West Brazil (COMPANHIA DE DESENVOLVIMENTO DO ESTADO DE GIOAS, 1979).

Between 1954 and 1977 beef prices exhibited a cyclical pattern of behaviour but with a tendency towards growth. Fig. 5.3 shows that beef prices rose to a certain limit (A) and then fell to a minimum level (B), repeating this behaviour with varied intensity throughout the period in question.

Figure 5.3

EVOLUTION OF BEFF PRICES



The amplitude of the cycle (horizontal dimension) is conditioned by biological factors and can also be affected by economic variables. In biological terms the cattle cycle in Brazil lasts nearly 7 years, which is the time that elapses between the birth of a cow and the moment at which its first calf reaches the age and suitable weight for slaughter.

The intensity of the cycle (vertical dimension), for its part, reflects the impact on market prices derived from the behaviour adopted by farmers as a result of their profit expectations.

In normal conditions farmers extract from their herds adult males, low productivity cows and the proportion of heifers that guarantee the maintenance of a defined group of reproductive cows. The rate of extraction is regulated by the objectives pursued by the farmer. That is to say, the rate of extraction can be regulated for keeping a constant number of animals (i.e. rate of extraction equals the herd's rate of growth), for increasing the herd or for reducing it.

Due to the interrelationships that exist between cows and future calves, the value farmers attribute to cows (reflecting their investment propensities) depends on future expectations concerning beef prices. Thus, if prices tend to decrease (*) profit expectations fall and there is no incentive for increasing breeding. This situation encourages farmers to increase the extraction of bullocks and cows. This process leads to an increasing supply of cattle which generates a further depression of beef prices which in turn confirms an increased rate of extraction that will then severely affect cows and even calves.

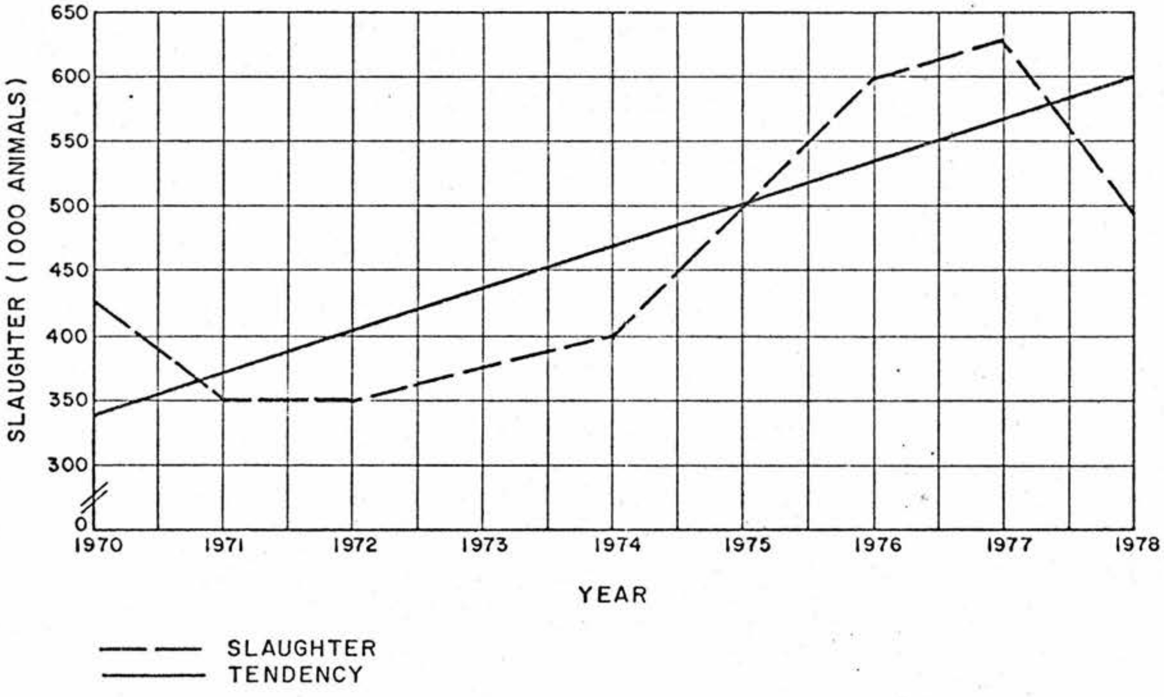
(*) These price expectations are explained in similar terms to those of agricultural products. See Section 5.2.1.

Each cow, heifer and calf extracted corresponds to a diminution in the future supply of adult animals. Prices will only rise again two or three years after the beginning of the phase of depression and this will happen when the beef market feels the lack of those animals withdrawn from the supply as a result of slaughter of cows and young cattle.

Increasing prices lead to optimistic expectations on the part of farmers, who react by trying to increase their herds. This entails the retention of cows and young animals, which leads to a reduction in supply which, in its turn, will force prices to rise. This process lasts until the new cattle reach the age of slaughter. At this point the increase in supply derived from the previous retention of cattle causes prices to show a downward tendency and the cycle begins again (see Fig. 5.4 and 5.5).

Figure 5.4

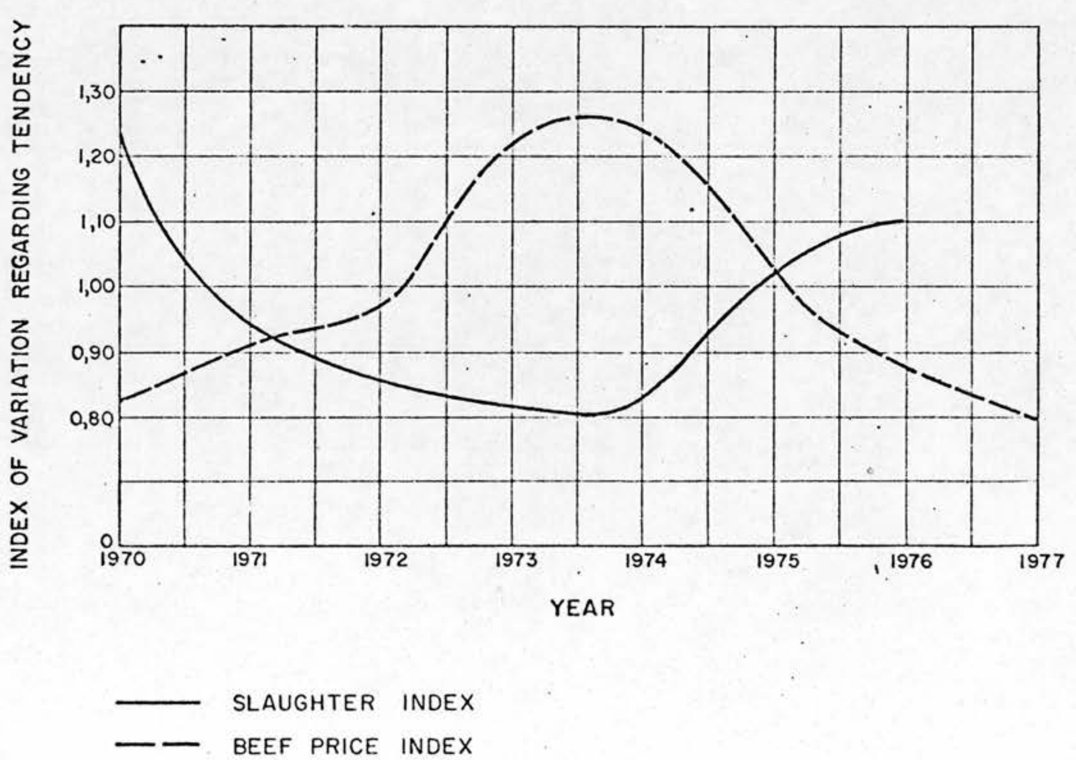
STATE OF GOIAS EVOLUTION OF CATTLE SLAUGHTER



The financial implications of the cattle cycle are very important. During the ascendant period farmers tend to contract debts (in order to finance the increase in their herds and investment in pastures and productive facilities) and they usually have serious liquidity problems during the downward period. This situation provides a good framwork for designing specific policies for controlling the process. In fact, increasing credits during the downward phase will tend to reduce cattle liquidation whereas a reduction of such credits in the rising period may encourage farmers to keep on selling, in order to obtain money for settling their financial commitments. Another possible measure for reducing the impact of the cycle is the implementation of special programmes for introducing technological changes with the aim of achieving a higher precocity of cattle, this is for reducing the length of the rearing period.

Figure 5.5

STATE OF GOIAS EVOLUTION OF BEEF PRICES
AND SLAUGHTER WITH REGARD TO THEIR TENDENCIES



The cattle raising sector of the simulation model adopts these ideas as a conceptual framework. It explains the evolution of cattle stock by means of a cohort-survival model (similar to the demographic one) where slaughters and transfers of cattle are represented by behavioural equations which consider expected prices, credit and a cattle-pasture ratio as exogenous variables.

Product and employment generated by this activity are derived from the cattle stock using equations that take into account the average productivity of cattle and labour respectively. Let us now examine the structure of this sector of the economic submodel.

The total head of cattle of each programme-area is obtained by the aggregation of six groups defined in terms of three cohorts for both sexes.

$$\text{(CAT-1)} \quad GADO(A,T) = \sum_{E=1}^{3} \sum_{S=1}^{2} GADO(E,S,A,T)$$

GADO(A,T) = total head of cattle, programme-area A, year T
GADO(E,S,A,T)=cattle age cohort E,sex S,programme-area A, year T
E = 1(0-1 year of age); 2(1-2 years of age); 3(over 2 years of age)
S = 1 (Male); 2 (Female)

The first cohort includes only animals up to one year of age, thus this group is formed by the calves born the previous year minus those who die. Initially, a behavioural equation was tried in order to explain the reproduction pattern of cattle in terms of farmers' profit expectations.As the results were inconclusive and after some empirical analyses such a function was disregarded, since in extensive cattle raising (as is practised in the study area) there is no important control of reproduction on the part of farmers.

In this way the number of calves under one year of age is obtained by multiplying the number of cows by an average rate of reproduction. Due to lack of empirical evidence the number of animals of each sex was assumed to be equal. Thus we have:

(CAT-2) GADO(1,S,A,T)=0.5*GADO(3,2,A,T-1)*TNAT(T)*TSOB(1,S,T)

Where
TNAT(T) = Birth rate, year T
TSOB(1,S,T) = Survival rate, cohort 1, sex S, year T

Cattle between one and two years of age equals the stock of the previous cohort in year T-1, adjusted by mortality and transfers to other programme-areas.

(CAT-3) GADO(2,S,A,T)=GADO(1,S,A,T-1)*TSOB(2,S,T)*TRANSF(A,T)
TRANSF(A,T) = Rate of transfer between programme-areas, programme-area A, year T

Cattle over two years of age in year T are represented by the number of animals in this cohort the previous year minus the cattle extracted (for slaughter or exported to other states), plus the animals in the second cohort in year T-1. All adjusted by mortality and transfers to other programme-areas.

(CAT-4) GADO(3,S,A,T)= [GADO(3,S,A,T-1)*(1-PEXT(S,T-1) + GADO(2,S,A,T-1)] *TSOB(3,S,T*TRANSF(A,T)
PEXT(S,T-1) = Rate of extraction, cattle sex S, year T-1

The number of jobs generated by this activity in each programme-area is determined multiplying the stock of cattle by a coefficient of labour requirement per animal.

$$(CAT\text{-}5)\ EMPEC(A,T) = \sum_{E=1}^{3} \sum_{S=1}^{2} GADO(E,S,A,T) * RQMPE(T)$$

EMPEC(A,T) = Cattle raising employment, programme-area A, year T
RQMPE(T) = Labour requirement per unit of cattle, year T

Gross production in extensive cattle raising devoted almost exclusively to beef production equals the number of animals extracted (for slaughter, live export or transfer to other programme-areas), plus the increase in the stock multiplied by the average weight of animals and by price of live cattle.

The transfer coefficient is 1 where there are no transfers, higher than 1 where the programme area receives cattle and less than 1 where it sells. This way of constructing the coefficient makes it necessary to subtract transferred cattle for calculating gross product (*). Thus we have:

$$\text{(CAT-6)}\quad VPPEC(A,T) = \sum_{S=1}^{2} EXT(3,S,T)*PM(3,S)*PREC(T) +$$
$$\sum_{E=1}^{3}\sum_{S=1}^{2}\left[GADO(E,S,A,T)-GADO(E,S,A,T-1)\right]$$
$$*PM(E,S)*PREC(T)$$
$$-\sum_{T=2}^{3}\sum_{S=1}^{2} GADO(E,S,A,T)*(TRANSF(A,T)-1)*$$
$$PM(E,S)*PREC(T)$$

VPPEC(A,T) = Gross product of cattle raising, programme area A, year T

PM(E,S) = Average weight, cattle cohort E, sex S

PREC(T) = Price of beef to the farmer, year T

As mentioned above the behavioural equations of this sector of the model refer to the rates of transfer and extraction.

(*) This is due to the fact that when a programme area sells cattle it shows a negative balance in its transfer account. Since these transferred animals constitute production of the seller's programme area, it is necessary to add these animals to the cattle stock in order to calculate its gross output. This is done by subtracting the complement of the transfer coefficient multiplied by the head of cattle over one year of age. It is assumed that there is no transfer of calves under 1 year age.

Cattle transfers between programme areas originate from two main factors. Firstly, programme areas present different degrees of specialization in cattle activities. Some are specialized in breeding while others are mostly engaged in growing calves until they reach the age and weight for slaughter or for live export. This specialization largely depends on the quality of pasture, programme areas with low quality pasture being preferred for cattle breeding (i.e. Corumbá).

The second factor that generates cattle transfers is the process of agricultural frontier expansion. In fact the capacity to support cattle increases faster than cattle supply derived from the natural growth of existing herds. Thus, programme areas with high rates of growth of pasture become net buyers of cattle in order to bring about an equilibrium between their support capacity and their herds.

Due to the scarcity of reliable information regarding transfers of cattle an indirect estimation procedure was followed. Starting with the cattle stock for each programme area provided by the 1970's agricultural census, the herd was projected for 1975 using observed rates of birth, death, and extraction. Net transfers for each programme area were then calculated as the differences between that projection and the cattle provided by the 1975 census.

Programme areas that received transfers registered positive balances while the selling ones presented a negative balance. Net transfers were expressed as average annual rates for the period 1970-75 constituting the dependent variable of the behavioural equation. After trying some independent variables the cattle-pasture ratio for the period 1970-75 was selected (see Table 5.8). Regression analysis performed on a double logarithmic function produced the best fit. Thus we have:

(CAT-7) LOG(TRANSF(A)) = 0.0586-0.1211 LOG(ANPP(A))
(3.53) (-4.03)

TABLE 5.8

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
ANTECEDENTS FOR DETERMINING CATTLE TRANSFER COEFFICIENT 1970 - 1975

PROGRAMME AREAS	NUMBER OF ANIMALS			NET ANNUAL TRANSFERS	% OF THE AVERAGE STOCK (1970-75)	TRANSFER COEFFICIENT (1+TRANSF)	CATTLE PASTURES RATIO (1970-75)
	CENSUS 1975	PROJECTION 1975	NET TRANSFERS 1970-75				
1) ALTO PARAGUAY	316,942	127,60	189,272	37,854	19.01	1.1901	0.91
2) CÁCERES	346,707	418,460	- 71,753	- 14,351	- 4.65	0.9535	2.28
3) CUIABÁ	885,140	1,177,851	- 292,711	- 58,542	- 7.18	0.9282	2.73
4) RONDONÓPOLIS	696,823	598,167	98,656	19,731	3.41	1.0341	1.19
5) BARRA DO GARÇA	631,516	499,024	132,492	26,498	5.69	1.0569	0.98
6) DIAMANTINO	232,991	149,821	83,170	16.634	10.28	1.1028	0.55
STATE OF MATO GROSSO							
7) ALTO TAQUARI	656,174	819,593	- 163,419	- 32,684	- 5.49	0.9451	1.44
8) CAMPO GRANDE	763,796	859,550	- 95,754	- 19,151	- 2.91	0.9709	1.21
9) BODOQUENA	1,155,460	1,479,863	- 324,403	- 64,881	- 6.09	0.9391	2.79
10) CORUMBÁ	2,484,660	3,026,712	(*)	(*)	(*)	(*)	(*)
11) TRÊS LAGOAS	1,157,101	1,161,232	- 4,131	- 826	- 0.08	0.9992	1.20
12) DOURADOS	2,653,963	2,204,642	449,321	89,864	4.18	1.0418	1.17
STATE OF MATO GROSSO DO SUL							
TOTAL REGION							

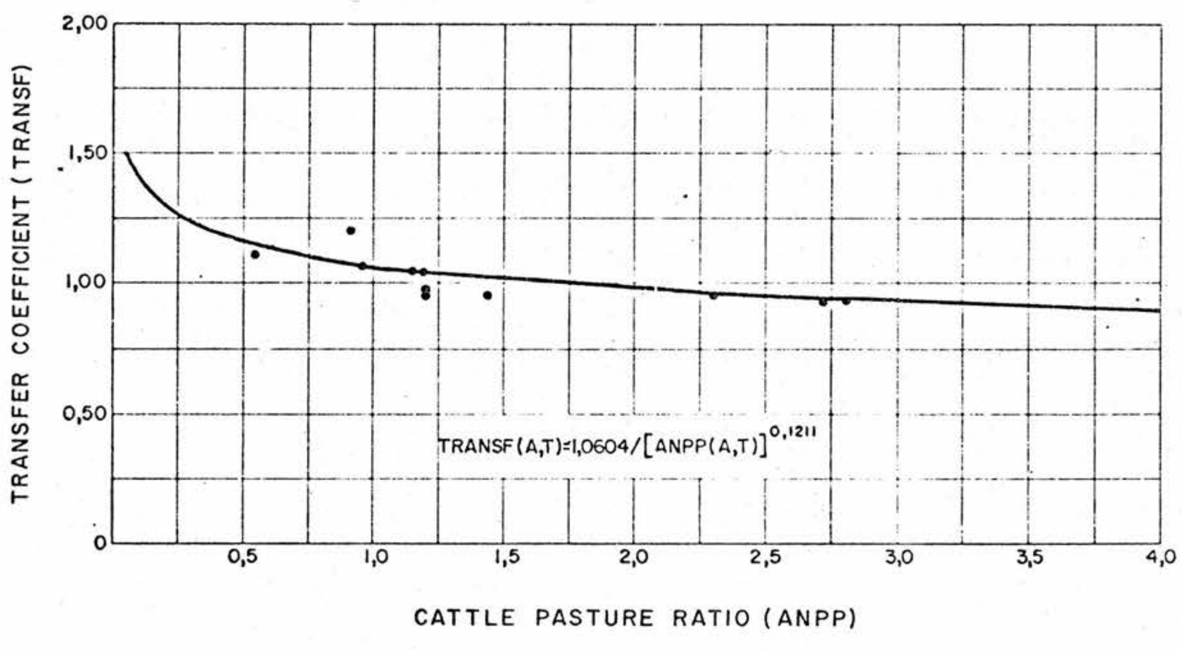
(*) Cattle stock in Corumba was reduced by 523277 animals between 1970 and 1975, because of the floods that occurred during that period. In order to avoid distortions Corumba was excluded from the sample.

Where
LOG(TRANSF(A))=log transfer coefficient, programme area A
LOG(ANPP(A)) =log cattle/pasture ratio, programme area A
$F = 16.27$
$R^2 = 0.64$

In this way the behavioural equation to be introduced into the model presents an inverse relationship between this transfer coefficient and the cattle/pasture ratio (see Fig. 5.6). Its numerical expression is:

$$\text{(CAT-7*)} \quad \text{TRANSF}(A,T) = \frac{1,0604}{(\text{ANPP}(A,T))^{0.1211}}$$

Figure 5.6
EXPLANATORY FUNCTION OF CATTLE TRANSFER COEFFICIENT(*)



(*) The cattle/pasture ratio is expected to change over time. Since the model is able to reproduce its behaviour in each run, it was preferred to include the time dimension in this function.

Cattle extraction rates, for their part, reflect the proportion of animals over 2 years of age that are extracted each year to form the herd for slaughter or live export to other states. Because of some inconsistencies between data from different sources, quantifying these rates was quite hard and some estimates were necessary.

It was assumed that extracted cattle were utilized for local consumption, exported alive or exported as frozen meat. Live cattle exported was estimated from interregional commerce statistics (*). After checking the consistency between meat export statistics and data on slaughtering under Federal control it was assumed that the latter data correspond to the export of frozen meat. Finally internal consumption was estimated on the basis of studies carried out by EDIBAP and some official publications (**).

Obviously, this estimation procedure involved some risk of error. For example, it was detected that interregional commerce statistics underestimate the number of cattle exported alive since they do not include the movements of cattle not constituting official commercial transactions.

In order to minimize such estimation errors the cattle sector of the model was simulated for reproducing the evolution of the regional stock of cattle between the agricultural censuses of 1960, 1970 and 1975. These simulations were performed using average rates of reproduction and mortality and preliminary extraction rates. Starting with the stock of cattle provided by the census of 1960, an expected stock for 1970 was obtained by means of such rates.The difference between actual and expected stock for 1970 was used to recalculate extraction for live cattle exports and for internal consumption. This process was repeated for the period 1970-1975.

(*) FIBGE, COMERCIO POR VIAS INTERNAS (Commerce by internal ways).

(**)EMATER, 1977; SUPLAN, 1972; CEPA-MT, 1978-79

Once a time series for the States of Mato Grosso and Mato Grosso do Sul for the period 1960-79 has been constructed, extracted cattle was expressed as an average annual rate for both sexes (see Table 5.9).

According to the cattle cycle explained above these rates of extraction were expressed as a function of observed market prices and credit granted to cattle raising. In the same way as in the agricultural sector of the model a lagged function was tried using a two year lag with the dependent variable and prices and credit with a one year lag.

(CAT-8) PEXT(3,1,T) = 37.1+0.35*PEXT(3,1,T-1) -
(3.96) (1.70)
-0.5*PEXT(3,1,T-2)-0.066*PRECA(T-1)+0.006*CRPE(T-1)
(-2.50) (-2.27) (4.76)

F = 13.60
R^2= 0.92
DW= 3.34

(CAT-9) PEXT(3,2,T)=11.75+0.4531*PEXT(3,2,T-1)-0.4799*PEXT(3,2,T-2)
(3.23) (1.50) (-1.53)
-0.0177*PRECA(T-1)+0.0018 CPRC(T-1)
(-2.14) (1.71)

F = 23.48
R^2= 0.74
DW= 2.72

Where

PEXT(3,S,T) = extraction rate, cattle cohort 3, sex S, year T
PRECA(T-1) = price of beef to the farmer, year T-1
CRPE(T-1) = total loans granted to cattle raising in both states, year T-1
CRPC(T-1) = loans granted for normal expenses of cattle raising in both states, year T-1 (excluding loans for investment).

TABLE 5.9

STATES OF MATO GROSSO AND MATO GROSSO DO SUL. ESTIMATION OF CATTLE EXTRACTION

	SLAUTERING UNDER FEDERAL CONTROL			EXPORTED ALIVE			INTERNAL CONSUMPTION			TOTAL EXTRACTION			EXTRATION RATE		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
1960	63.867	31.807	95.674	300.989	87.685	388.674	10.540	94.855	105.385	375.386	214.347	589.743	43,05	7,49	15,79
1961	59.885	27.405	87.290	283.025	97.487	380.512	11.168	100.511	111.679	354.078	225.403	579.481	37,79	7,54	14,76
1962	59.415	28.861	88.276	286.562	94.910	381.472	11.834	106.498	118.332	357.811	230.269	588.080	35,54	7,38	14,26
1963	61.606	30.122	91.728	335.459	110.630	446.089	12.538	112.841	125.379	409.603	253.593	663.196	37,86	7,79	15,30
1964	69.821	36.702	106.523	267.260	93.609	360.869	13.286	119.567	132.853	350.367	249.878	600.245	30,13	7,36	13,17
1965	76.208	38.206	114.414	324.783	122.207	446.990	15.359	138.229	153.588	416.350	298.642	714.992	33,32	8,43	14,92
1966	86.021	42.202	128.223	329.786	123.158	452.954	16.272	146.439	162.711	432.089	311.799	743.888	32,18	8,43	14,76
1967	100.875	45.101	145.976	388.827	117.590	506.417	17.241	155.164	172.405	506.943	317.855	824.798	35,13	8,24	15,56
1968	105.996	49.351	155.347	415.151	144.729	559.880	18.268	164.406	182.674	539.415	358.486	897.901	34,78	8,90	16,10
1969	116.884	57.696	174.580	369.843	137.626	507.469	19.360	174.228	193.588	506.087	369.550	875.637	30,37	8,79	14,92
1970	107.123	109.869	216.992	299.863	116.324	416.187	22.218	199.961	222.179	429.204	426.154	855.358	23,96	9,72	13,85
1971	151.006	77.863	228.869	291.996	89.798	381.794	23.427	210.847	234.274	466.429	378.508	844.937	21,74	8,20	12,99
1972	136.798	67.166	203.964	294.289	109.167	403.456	24.714	222.423	247.137	455.801	398.756	854.557	22,95	8,20	12,48
1973	143.067	59.371	207.438	416.124	138.968	555.092	26.027	234.247	260.274	590.218	432.586	1.022.804	23,22	8,45	14,19
1974	160.660	51.847	212.507	417.817	88.947	506.763	27.451	247.054	274.505	605.927	387.848	993.775	27,51	7,20	13,09
1975	206.452	72.471	278.923	411.550	87.256	498.806	28.928	260.356	289.284	646.930	420.083	1.067.013	27,90	7,40	13,35
1976	267.724	120.206	387.930	517.453	146.306	663.759	30.486	274.73	304.859	815.663	540.885	1.356.548	33,40	9,06	16,12
1977	353.576	172.485	526.061	673.311	209.534	882.845	32.127	289.145	321.272	1.059.014	671.174	1.730.178	41,19	10,67	19,53
1978	339.645	170.461	510.106	590.063	202.031	792.094	33.857	304.712	338.569	963.565	677.204	1.640.769	35,60	10,23	17,59
1979	337.434	118.692	456.126	569.763	169.785	739.548	35.680	321.117	356.797	942.877	609.594	1.552.471	33,08	8,74	15,81

SOURCE: EDIBAP, 1980.

As expected these functions presented problems of serial correlation. Since these functions also have the dependent variable lagged in two periods, the BOX and JENKINS method was utilised for identifying and estimating the autoregressive models. Thus two new functions containing a greater lag of independent variables were obtained.

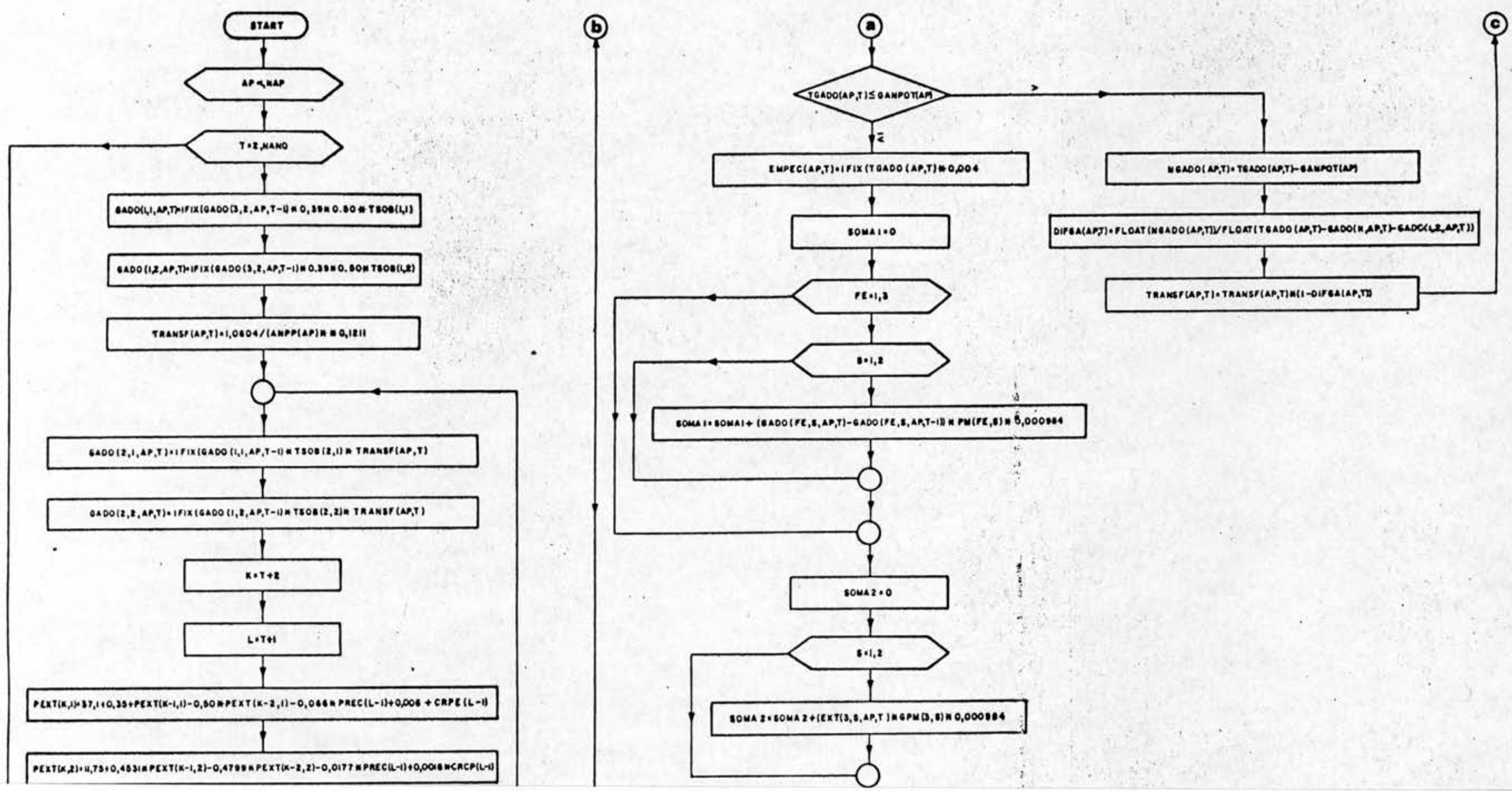
(CAT-8*) PEXT(3,1,T)=37.23-0.4329*PEXT(3,1,T-1)-0.2350*PEXT(3,1,T-2)
-0.3926*PEXT(3,1,T-3)-0.66*PRECA(T-1) -
-0.005*PRECA(T-2)+0.006*CRPE(T-1) +
0.0047*CRPE(T-2)

(CAT-9*) PEXT(3,2,T)=11.722+0.7038*PEXT(3,2,T-1)-0.5935*PEXT(3,2,T-2)
+0.12003*PEXT(3,2,T-3)-0.0177*PRECA(T-1) +
0.0044 *PRECA(T-2)+0.0018*CRPC(T-1)-0.0005*
CRPC(T-2)

These new functions imply a reduction of the problem of auto regression (94% and 87.6% respectively) and are consistent with empirical observations on the cattle cycle. They were therefore regarded as acceptable for the purposes of the model.

The main features of the structure of this sector of the model are schematically presented in the flowchart of the computer programme (see Fig. 5.7).

Economic Submodel-Cattle Raising Sector



5.3 INDUSTRY

Due to a lack of statistical information about its past behaviour this sector of the economic submodel has been developed at a much more general level than the previous ones. Not only does regional industry, nowadays, make a lower contribution to regional product and employment than agriculture and cattle raising, but also its role in future development of the States of Mato Grosso and Mato Grosso do Sul has not been sufficiently emphasized by national or regional development policies. In spite of this adverse situation, the development strategy designed by EDIBAP for the Upper Paraguay River Basin attributes to the industrial sector a major role for dynamising the regional economy. Consistent with this approach to regional development, the model treats the industrial sector as accurately as the limited information available permits.

Thus, in terms of the role this sector is expected to play in future regional development, as well as the variables that explain its behaviour, four industrial branches were defined for the purposes of modelling. These are timber related industries, mining, export orientated industries and residentiary industries (see Tables 5.10 and 5.11). The timber industry is one of the most important individual industrial activities (*) of the region both in terms of output and employment. However, it presents a special type of behaviour. The timber industry consists of small factories (on average lower than 10 persons per firm in 1975), basically engaged in the primary transformation of native wood and characterized by low technological levels.

Empirical studies carried out by EDIBAP demonstrated that this activity is strongly linked with the deforestation process that results from the expansion of the agricultural frontier. This means that the level of activity of the timber industry increases with agricultural expansion and

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(*) According to the Standard Industrial classification

TABLE 5.10

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

STRUCTURE OF INDUSTRIAL EMPLOYMENT

PROGRAMME AREAS	1970					1975				
	TIMBER INDUSTY	MINING	EXPORT INDUSTRY	DIVERSE INDUSTRIES	TOTAL	TIMBER INDUSTRY	MINING	EXPORT INDUSTRY	DIVERSE INDUSTRIES	TOTAL
1) ALTO PARAGUAY	241	156	-	223	620	592	156	-	314	1,062
2) CÁCERES	213	54	-	243	510	637	446	-	882	1,965
3) CUIABÁ	324	1,251	381	1,152	3,108	1,052	3,184	562	2,505	7,303
4) RONDONÓPOLIS	241	965	-	742	1,948	302	882	-	1,164	2,348
5) BARRA DO GARÇA	16	59	-	118	193	89	156	-	176	421
6) DIAMANTINO	57	38	-	28	123	105	5	-	87	197
STATE OF MATO GROSSO	1,092	2,523	381	2,506	6,502	2,777	4,829	562	5,128	13,296
7) ALTO TAQUARI	16	180	-	242	438	126	212	-	308	646
8) CAMPO GRANDE	304	1,516	762	3,101	5,683	515	1,681	1,126	6,204	9,526
9) BODOQUENA	154	775	134	623	1,686	207	175	197	215	794
10) CORUMBÁ	172	2,342	-	1,215	3,729	233	1,022	-	1,667	2,922
11) TRÊS LAGOAS	363	2,367	288	532	3,550	493	3,064	424	1,140	5,121
12) DOURADOS (*)	2,210	1,189	345	1,586	5,330	4,867	2,321	509	2,898	10,595
STATE OF MATO GROSSO DO SUL	3,219	8,369	1,529	7,299	20,416	6,441	8,475	2,256	12,432	29,604
TOTAL REGION	4,311	10,892	1,910	9,805	26,918	9,218	13,304	2,818	17,560	42,900

SOURCE: (Demographic Census 1970, Industrial Censuses 1970 and 1975)
(*): Because of an inconsistency between Demographic and Industrial Censuses for 1970, 2 148 jobs were transferred from Timber Industry in the Programme-area of Dourados to civil construction.

TABLE 5.11

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
STRUCTURE OF INDUSTRIAL ADDED VALUE
(1000 CR$ 1980)

PROGRAMME AREAS	1970					1975				
	TIMBER INDUSTRY	MINING	EXPORT INDUSTRY	DIVERSE INDUSTRIES	TOTAL	TIMBER INDUSTRY	MINING	EXPORT INDUSTRY	DIVERSE INDUSTRIES	TOTAL
1) ALTO PARAGUAY	14,993	3,245	-	10,608	28,846	70,494	12,697	-	32,268	115,459
2) CÁCERES	43,593	5,655	-	28,884	78,132	100,997	24,518	-	120,590	246,105
3) CUIABÁ	23,342	45,471	77,000	66,663	212,476	157,143	352,797	113,974	595,925	1,219,839
4) RONDONÓPOLIS	10,172	24,381	-	52,664	87,217	18,711	32,453	-	125,665	176,829
5) BARRA DO GARÇA	247	531	-	8,469	9,247	3,060	5,793	-	13,515	22,368
6) DIAMANTINO	3,454	2,903	-	2,885	9,242	9,302	1,011	-	11,693	22,006
STATE OF MATO GROSSO	95,801	82,186	77,000	170,173	425,160	359,707	429,269	113,974	899,656	1,802,606
7) ALTO TAQUARI	626	8,369	-	23,153	32,148	11,359	6,249	-	45,997	63,605
8) CAMPO GRANDE	17,839	66,973	154,000	693,159	931,971	80,821	159,705	227,950	1,199,450	1,667,926
9) BODOQUENA	7,857	21,502	27,100	30,934	87,393	41,763	25,749	39,891	40,951	148,354
10) CORUMBÁ	10,495	347,829	-	137,773	496,097	29,820	321,375	-	282,353	633,548
11) TRÊS LAGOAS	21,407	108,213	58,300	13,987	201,907	48,837	281,178	85,480	102,565	518,060
12) DOURADOS	156,929	70,598	69,800	208,949	506,276	619,200	148,532	102,577	359,337	1,229,646
STATE OF MATO GROSSO DO SUL	215,153	623,484	309,200	1,107,955	2,255,792	831,800	942,788	455,898	2,030,653	4,261,139
TOTAL REGION	310,954	705,670	386,200	1,278,128	2,680,952	1,191,507	1,372,057	569,872	2,930,309	6,063,745

SOURCE: CENSOS INDUSTRIALES 1970; 1975 (INDUSTRIAL CENSUSES 1970, 1975) decreases when this process comes to an end (see Fig.5.8). Since timber is an important input in civil construction and also constitutes raw material for local service industries, it is assumed that when deforestation comes to an end the level of activity of the timber industry is reduced to a level that matches the requirements of local markets. For this reason the model explains the behaviour of this branch of industry as a function of deforestation subject to a minimum constraint. This constraint is defined as the product per capita of the timber industry at the national level multiplied by the population of each programme-area.

Following this criterion a behavioural function was quantified by means of OLSQ on cross-section data derived from the agricultural and industrial censuses of 1975.

$$\text{(IND-1)}\ VAMAD(A,T) = -\underset{(-4.69)}{56.49} + \underset{(20.9)}{0.0101}*DESMAT(A,T) \geqslant POP(A,T)*PPNIM$$

VAMAD(A,T) = added value of timber industry, programme area A, Year T.

DESMAT(A,T) = deforested area, programme area A, Year T (expressed in hectares)

POP(A,T) = total population, programme area A, Year T

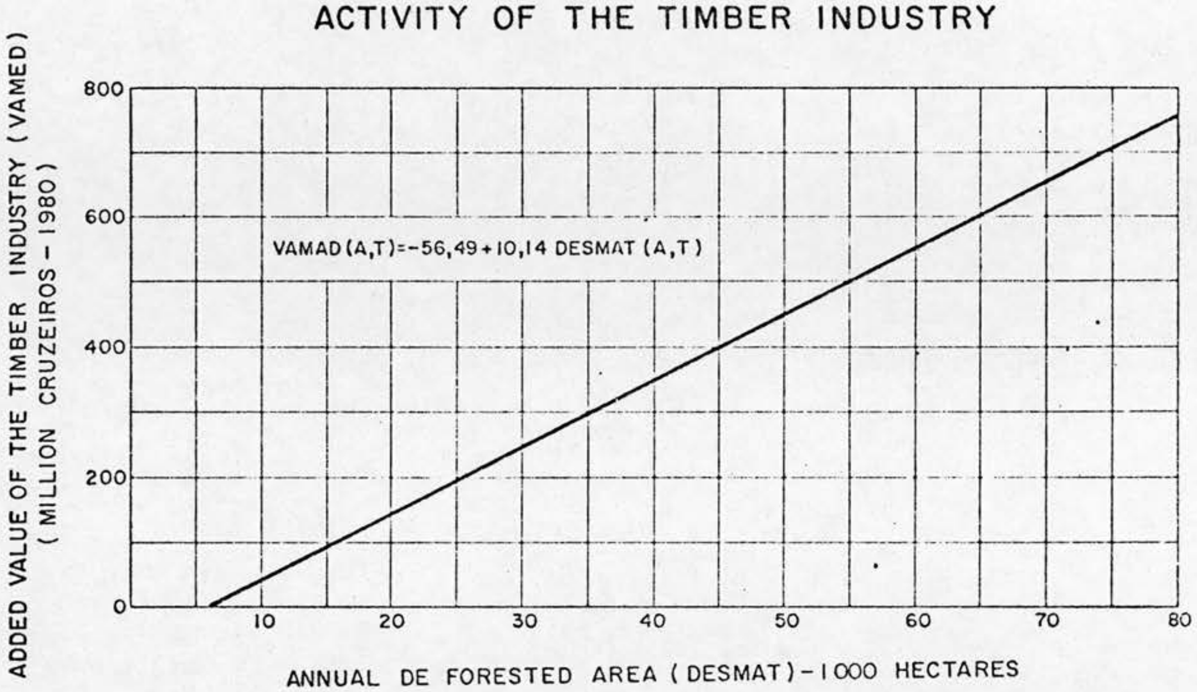
PPNIM = national product per capita, timber industry (year 1975)

$F = 436.7$

$R^2 = 0.98$

Figure 5.8

EXPLANATORY FUNCTION OF THE LEVEL OF ACTIVITY OF THE TIMBER INDUSTRY



Employment generated by this activity is obtained by multiplying the added value by a labour requirement coefficient. This coefficient represents the inverse of the average productivity of labour and is expected to change with time. Owing to the lack of historical data no function for explaining variations of labour productivity could be defined, leaving this aspect as a matter for objectives formulation.

(IND-2) ENIMA(A,T)=VAMAD(A,T)*REQMO(1,T)

ENIMA(A,T)=employment generated by timber industry,programme area A, year T

REQMO(1,T)=labour requirements per unit of product,timber industry, year T

Mining is a special industry in the study area.It represents a significant level of activity but behaves as an enclave in the regional economy. In fact the mining industry consists of a few big firms engaged in extractive activities with a low level of transformation in the region. Its products are exported to other regions except for chalk which is partially utilized for improving land productivity in the area.

The level of activity of mining industries is controlled by the Brazilian Ministry of Mines and Energy which authorizes the exploitation of mineral deposits by granting special concessions. Because of this, the model assumes that the level of activity of these industries follows the objectives defined by sectoral policies. Thus, the added value of mining is expressed as the level registered in the base year modified by a rate of growth exogenously defined.

Employment is determined in a similar way to that of the timber industry. Thus, we have:

(IND-3) VAMIN(A,T)=VAMIN(A,T-1)* (1+METMIN(A,T))

(IND-4) EMIMI(A,T)=VAMIN(A,T)*REQMO(2,T)

Where

VAMIN(A,T) = added value of mining industries,programme area A, year T

METMIN(A,T)= rate of growth of mining industries, programme area A, year T (objective)

EMIMI(A,T) = employment generated by mining industries,programme area A, year T

REQMO(2,T) = labour requirements per unit of product,mining industry, year T

The third subsector of regional industry was defined as export industry. Although timber and mining industries also export their products to other regions (and even to other countries) this denomination was utilized for identifying a group of industries engaged in the transformation of primary products originating in the region. As such these industries are complementary to the regional economic base and their products are mostly exported.

Although this type of industry was quite insignificant in 1975 (it represented only 6.6% of industrial employment and 9.3% of regional industrial product), it was deemed necessary to treat this subsector independently from the rest of industry due to the fact that the strategy defines an important role for these industries in the future development of the region.

Industries engaged in the processing of regional primary products are assumed to benefit regional development in two principal ways. On the one hand they must generate purchasing power for agricultural and cattle products which may lead to higher and more stable prices for farmers. The increased prices received by farmers is assumed to be the result of a reduction in transport costs between farm and industry, while greater price stability may derive from the complementarity that may exist between primary and secondary activities. This price effect is expected to stimulate agriculture and cattle raising activities.

On the other hand, export industries lead to a greater value of exports which increases regional import capacity, and also, expands the level of activity of the regional economy though the export base multipliers.

Since the current level of activity of these industries in the region is very low, any significant increase will mean an addition to productive capacity many times greater than the existing one. For this reason it was considered too risky to try to explain the future behaviour of this subsector by means of a behavioural equation based on historical tendencies. Thus, its future development is assumed to be the outcome of specific policies.Consequently, the model explains the behaviour of export industry in the same way as the mining industry.

(IND-5) VAIEX(A,T) = VAIEX(A,T-1)*(1+METIEX(A,T))

(IND-6) EMIEX(A,T) = VAIEX(A,T)*REQMO(3,T)

VAIEX(A,T) = added value of export industry, programme area A, year T

METIEX(A,T) = rate of growth of export industry, programme area A, year T (objective)

EMIEX(A,T) = employment generated by export industry,programme area A, year T

REQMO(3,T) = labour requirement per unit of product,export industry, year T

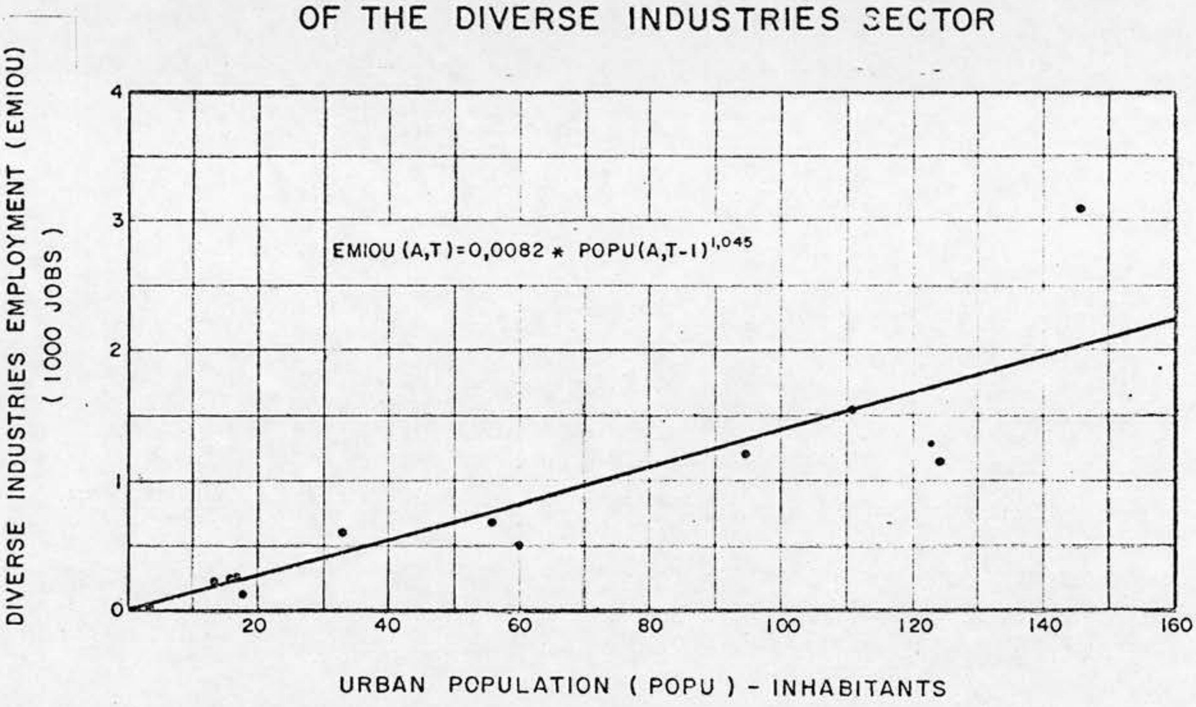
The rest of regional industry consists of a great variety of small firms (with an average of less than 6 employees each in 1975), mainly engaged in serving local markets.As such, this industrial subsector together with commerce and services, constitutes what export-base theory refers to as the domestic and residentiary sector.

This theory establishes that the behaviour of domestic sectors depends on the rate of growth of the regional market, which for its part is a function of the behaviour of the export sector. Due to a lack of information about the historic behaviour of the export sector and this sector of diverse industries, an indirect procedure was followed for estimating a behavioural function.

The size of the internal market of each programme area is a function of its population, the level of income and its pattern of distribution. Since there is no information regarding income distribution at the regional level and as estimates of income were highly unreliable, population was taken as the independent variable. After a few trials employment generated by diverse industries was expressed as a double logarithmic function of urban population of each programme area (see Fig. 5.9).

Figure 5.9

EXPLANATORY FUNCTION OF THE LEVEL OF ACTIVITY OF THE DIVERSE INDUSTRIES SECTOR



(IND-7) LOG(EMIOU(A,T))=-4.803+1.045*LOG(POPU(A,T-1))
(-5.08)(11.62)

LOG(EMIOU(A,T)) = log. employment generated by diverse in dustries,programme area A,year T

LOG(POPU(A,T-1) = log. urban population, programme area A, year T-1

F = 134.94

R^2= 0.93

Consequently, the equation to be incorporated into the model is obtained by applying an antilogarithm to the results of the equation (IND-7). Added value of the diverse industries sector results from multiplying the level of employment by the average productivity of labour. Thus, we can write:

(IND-7*) $\mathrm{EMIOU(A,T)} = 0.0082*\mathrm{POPU(A,T-1)}^{1.045}$

(IND-8) VAIOU(A,T) = EMIOU(A,T)/REQMO(4,T)

Where

VAIOU(A,T) = added value of diverse industries sector, programme area A, year T

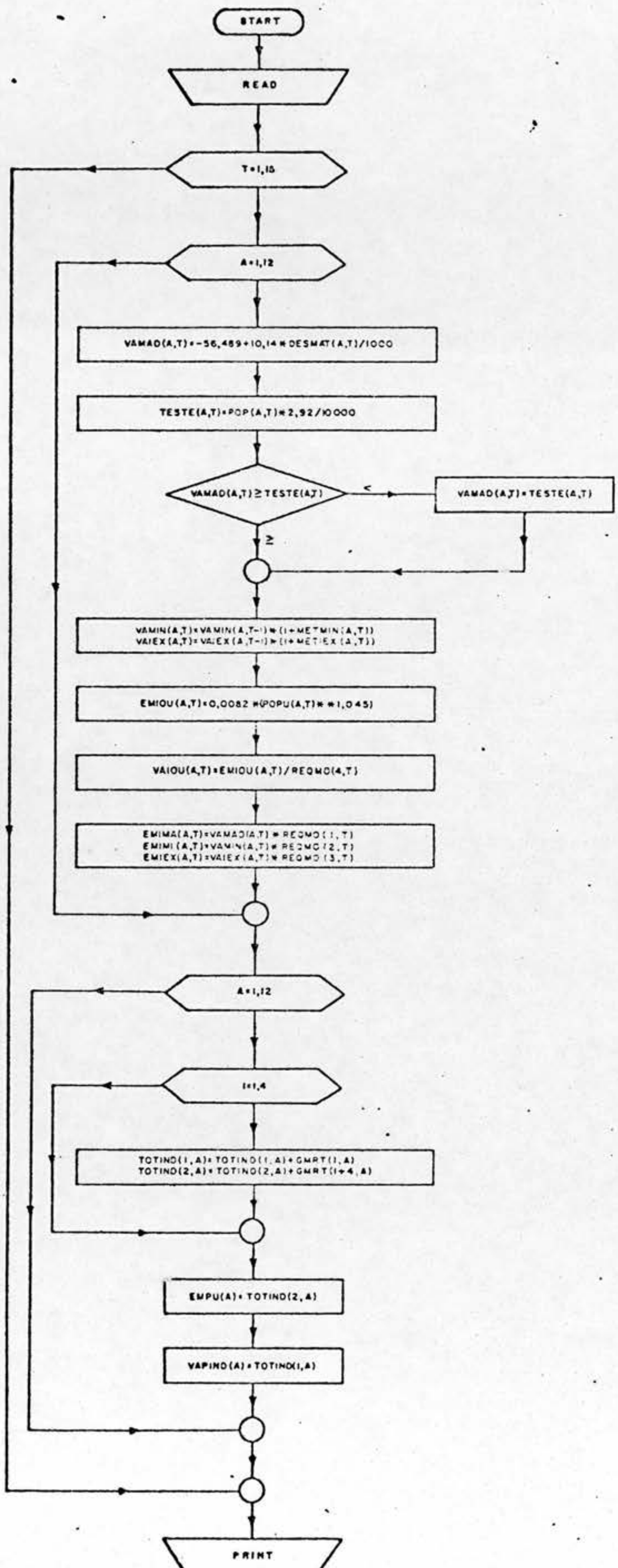
REQMO(4,T) = labour requirement per unit of product, diverse industries sector, year T. (This coefficient equals the reciprocal of average productivity of labour)

Fig. 5.10 contains the flowchart of the computer programme of this subsector.

Figure 5.10

FLOW CHART

ECONOMIC SUBMODEL–INDUSTRIAL SECTOR



EDIBAP

5.4 CIVIL CONSTRUCTION, COMMERCE, SERVICES AND GOVERNMENT

This sector of the economic submodel comprises a group that, although very important for the regional economy in quantitative as well as qualitative terms, was treated in a relatively marginal way by the model. This rough treatment is primarily due to a lack of information and to a lesser extent to the fact that development proposals formulated by EDIBAP exclude these sectors.

Thus, the inclusion of these activities into the model has to be seen mainly as an attempt at completing the scope of the economic submodel and consequently reproducing regional accounts, rather than as an attempt to explain their behaviour for planning purposes.

Available information about these sectors consists of the findings of the Censuses (1960 and 1970) and some estimates of the sectoral product for 1975 (see Table 5.12).

For explaining the behaviour of civil construction it was assumed that this sector is highly dependent on the behaviour of public works (especially the construction of roads) and residential building.

The volume of resources devoted to public works is defined politically at the national level since they are almost wholy financed through the Federal Budget. Residential building for its part is greatly influenced by the financial resources channelled by the Federal Government through the National Housing Bank (Banco Nacional de Habitação - BNH).

TABLE 5.12

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

STRUCTURE OF EMPLOYMENT AND ADDED VALUE OF SECTORS CIVIL CONSTRUCTION, COMMERCE AND SERVICES, AND GOVERNMENT (1970)

PROGRAMME AREAS	EMPLOYMENT				ADDED VALUE (MILLION CR$ APRIL 1980)			
	CIVIL CONSTRUCTION	COMMERCE AND SERVICES	GOVERNMENT	TOTAL	CIVIL CONSTRUCTION	COMMERCE AND SERVICES	GOVERNMENT	TOTAL
1) ALTO PARAGUAY	3,201	2,535	179	5,915	424	254	31	709
2) CÁCERES	869	3,735	945	5,549	115	375	165	655
3) CUIABÁ	6,103	21,889	3,742	31,734	808	2,196	654	3,658
4) RONDONÓPOLIS	4,122	9,653	723	14,498	546	967	126	1,639
5) BARRA DO GARÇA	2,054	2,980	375	5,409	272	299	66	637
6) DIAMANTINO	785	852	153	1,790	104	85	27	216
STATE OF MATO GROSSO	17,134	41,644	6,117	64,895	2,269	4,176	1,069	7,514
7) ALTO TAQUARI	585	2,431	146	3,162	77	244	26	347
8) CAMPO GRANDE	3,781	27,649	4,909	36,339	501	2,775	858	4,134
9) BODOQUENA	393	5,126	1,252	6,771	52	515	219	786
10) CORUMBÁ	851	11,951	3,220	16,022	113	1,199	563	1,875
11) TRÊS LAGOAS	3,129	11,011	1,025	15,165	414	1,105	179	1,698
12) DOURADOS	2,646	21,551	2,218	26,415	350	2,164	387	2,901
STATE OF MATO GROSSO DO SUL	11,385	79,719	12,770	103,874	1,507	8,002	2,232	11,741
TOTAL REGION	28,519	121,363	18,887	168,769	3,776	12,178	3,301	19,255

SOURCE: Employment, Demographic Census 1970; Sectoral added value, estimates of EDIBAP.
NOTE: Employment of civil construction in the programme area of Dourados includes 2,148 jobs that the census considers in the timber industry.

Due to the fact that the Brazilian Government is applying a strict anti-inflation policy, it is reasonable to assume that both variables (public investment and housing loans) will be strongly controlled at the national level, and consequently their behaviour will reflect national policies rather than regional objectives.

In this way the level of activity of civil construction in the region is explained as a function of the loans granted by the National Housing Bank plus public investment in roads. Since the only available data consisted of the sectoral product for 1970 and 1975 and a historical series for housing loans and public investment in roads, the behavioural equation for this sector was quantified by means of the equation of the straight line that passes through two points.

Once the sectoral added value for the whole region had been quantified, it was disaggregated at the programme area level using a coefficient that represents the spatial objectives of housing and transport policies. Employment generated by civil construction is obtained by applying the reciprocal of the average productivity of labour to the added value of each programme area. Thus, we have:

(CSG-1) VACON(T) = 3,229.1 + 0.5456*IHARO(T)
(CSG-2) VACON(A,T) = VACON(T)*CODI1(A,T)
(CSG-3) EMCON(A,T) = VACON(A,T) * RMOCO(T)

VACON(T) = added value civil construction, year T
IHARO(T) = loans granted by BNH and public investment in roads in the States of Mato Grosso and Mato Grosso do Sul, year T
CODI1(A,T) = coefficient for spatial distribution of added value, civil construction, year T
EMCON(A,T) = employment generated by civil construction, programme area A, year T
RMOCO(T) = labour requirements per unit of product, civil construction, year T

In the case of the sector for commerce and services the procedure adopted was similar to that used for diverse industries because it was assumed that both activities formed the "domestic sector" of the regional economy. Thus sectoral employment is expressed as a function of the urban population of each programme area (see Fig. 5.11). In this case a linear function was quantified using OLSQ on cross-section data.

(CSG-4) EMCSE(A,T) = -326 + 0.186*POPU(A,T-1)
(-1.80) (33.3)

EMCSE(A,T) = employment generated by commerce and services, programme area A, year T

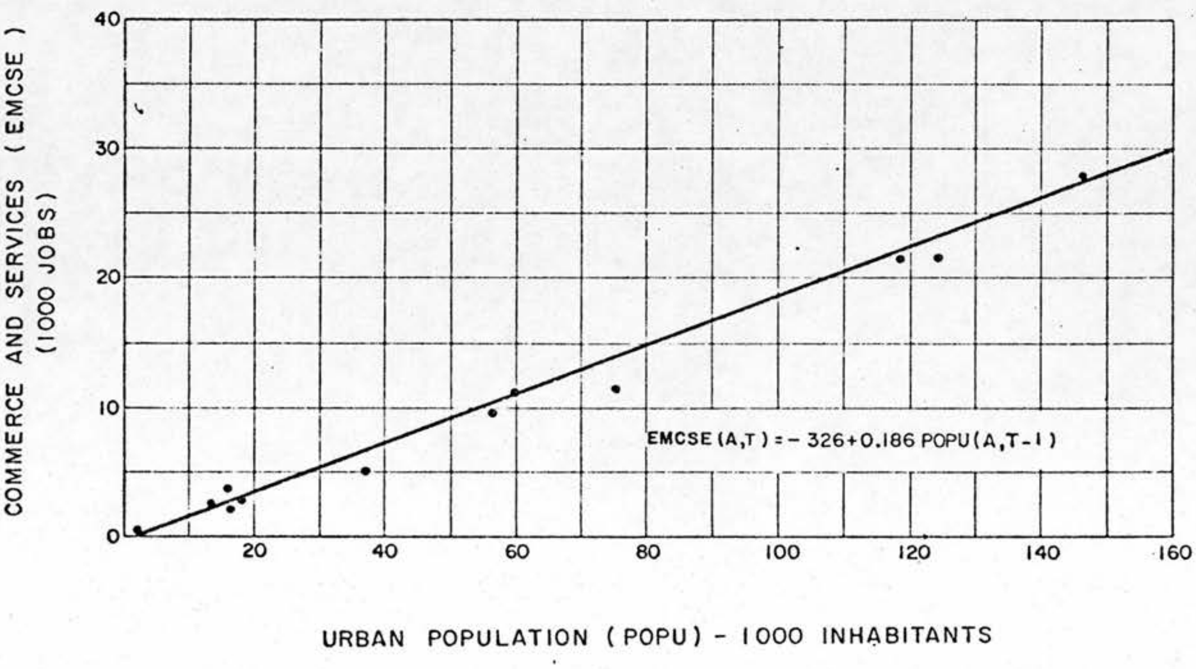
POPU(A,T-1) = urban population, programme area A, year T-1

F = 1111.2

R^2 = 0.99

Figure 5.11

EXPLANATORY FUNCTION OF THE LEVEL OF ACTIVITY OF COMMERCE AND SERVICES



Sectoral output is obtained by applying the average productivity of labour to the employment generated by this sector.

(CSG-5) VACSE(A,T) = EMCSE(A,T)/RMOCS(T)

VACSE(A,T) = added value generated by commerce and services, programme area A, year T

RMOCS(T) = labour requirements per unit of product, commerce and services, year T. (Reciprocal of average productivity of labour).

Finally, the economic behaviour of Government at the regional level is explained in similar terms to that of civil construction. In this case it was assumed that sectoral added value is a function of the behaviour of current expenditure of state governments. Thus, we have:

(CSG-6) VAGOB(T) = 7.78*(GCEST(T))$^{0.823}$
(CSG-7) VAGOB(A,T) = VAGOB(T)*CODI2(A,T)
(CSG-8) EMGOB(A,T) = VAGOB(A,T)*RMOGO(T)

Where

VAGOB(T) = added value of government, year T

GCEST(T) = current expenditure of state Governments of Mato Grosso and Mato Grosso do Sul, year T

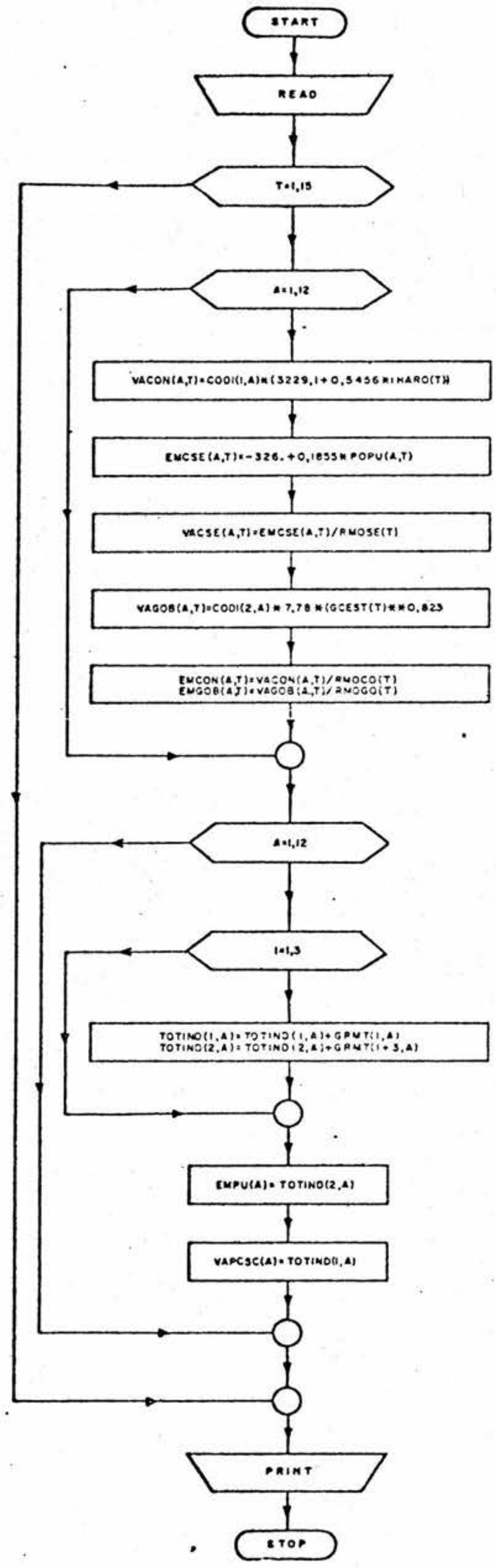
CODI2(A,T) = coefficient for spatial distribution of added value, sector government, year T

EMGOB(A,T) = employment generated by the government, programme area A, year T

RMOGO(T) = labour requirements per unit of product, government, year T

An overview of the structure of this sector of the economic submodel is presented in the flowchart of the computer programme contained in Fig. 5.12.

Figure 5.12
FLOW CHART
ECONOMIC SUBMODEL – TERCIARY SECTOR



EDIBAP

CHAPTER SIX

PHYSICAL AND ENVIRONMENTAL SUBMODEL

6. PHYSICAL AND ENVIRONMENTAL SUBMODEL

This part of the model fulfils two specific functions. In the first place, it is a means for explicitly introducing into the model the goals of a policy for the preservation of the environment in the form of norms for the use of natural resources. On the other hand, it determines the investments entailed by the pursuit of the social and spatial aims of the strategy.

With regard to the environmental impact of the occupation of space there exists a need to organize social and economic activities in such a way as to avoid the impairment of the natural ecosystems. To this end it is necessary to place restrictions on the exploitation of natural resources and set standards for regulating the process of urbanization, industrialization and large-scale engineering works.

With regard to the physical investments required by social and spatial policies, two factors have to be considered. In the first place, it is important to define the quantity of these investments accurately in order to permit a subsequent assessment of the financial feasibility of the strategy. On the other hand, the strengthening of the network of urban centres, the building of schools and hospitals, the extension of the road network, etc, are regarded as elements that condition the spatial functioning of the regional system. As such, their design and location should be defined in terms of the goal of spatial integration postulated by the strategy. For this purpose the model provides a spatial disaggregation of the shortages, which helps to enhance the accuracy of the decisions relating to the location of new investments.

6.1 THE ENVIRONMENTAL SECTOR

The incorporation of environmental goals into a strategy for regional development requires as its starting point that the relationships linking the physical environment to the social and economic systems operating in it be made explicit. These relationships, which are on the whole fairly clear, are based on the fact that social and economic activities require certain types of soil at particular geographical locations, and manifest different forms of spatial behaviour, whilst their operation modifies (both positively and negatively) the environment.

From another viewpoint, the interrelationships between the environment and the socio-economic systems that affect it generate a hierarchy that determines that the physical changes are a response to the requirements of the social and economic activities. Thus, human activities operate in the context of a physical structure which may be adapted to make possible the pursuit of its goals.

For the purposes of the model the deterioration of natural ecosystems was assumed to be the result of a series of factors, outstanding examples of which are predatory agriculture and cattle-raising and extractive activites, uncontrolled urban expansion, the insufficient treatment of industrial waste, and also certain deficiencies in the design of engineering works (dams, roads, etc,).

The study area has a low population density and also a marked under-use of land. For this reason an explicit consideration of restrictions on urban expansion was omitted, since the latter does not present any possible conflict- producing situations in the short or medium term.

On the other hand, as is argued in the chapter on environmental restrictions and precautions in the final report of EDIBAP, the contamination of surface water caused by urban and industrial waste is not at present a serious problem in the area, except in the case of the River Coxipó at Cuiabá. This problem could, however, become more acute in the event of the planned alcohol - related industries not being provided with satisfactory systems for the treatment of waste matter. Given that existing legislation on the preservation of the environment is considered to be sufficient to prevent these problems, the control of water contamination in the area should result from an improved surveillance of the enforcement of the regulations in force, and thus does not justify explicit treatment in the model.

Similarly, the prevention of cases of ecological disequilibrium arising from the construction of engineering works should be incorporated as a set of standards to be taken into consideration in the design of the projects in question.

As regards the use of natural resources for economic ends, maintaining the whole of the productive land under a use congruous with its potential capacity is presumed to constitute an obvious environmental (and economic) goal. Consequently, the submodel establishes a series of restrictions on land use that derive from potentiality studies of the natural resources.

The productive potential of the land is a result of the combination of physical, chemical and environmental characteristics associated with the soil. Determining this potential requires a series of basic studies concerning climatology, geology, vegetation, hydrology and drainage, physiomorphology, etc.

In general the aptitude of land depends on four basic factors that synthesize its principal physical, chemical and environmental attributes. These are fertility, degree of humidity, susceptibility to erosion and limitations on mechanization. (*)

Fertility is a measure of the availability of macro and micronutrients, and also includes the presence or absence of toxic substances such as aluminium, manganese, soluble salts, etc. The level of fertility is determined from the results of analyses carried out in a soil laboratory. The main indicators used are: capacity for cationic exchange, base saturation, saturation of aluminium, sum of the exchange bases, assimilable phosphorus, organic matter content, carbon-nitrogen relation, saturation of sodium, acidity and content of soluble salts.

The degree of soil humidity, for its part, concerns the availability of water in the soil in relation to the growth cycle of plants. This indicator depends on the rainfall , evapotranspiration and the water retention capacity of the soil. Its measurement is carried out by means of water deficiency indices and others concerning excess of water or lack of oxygen.

On the other hand, susceptibility to erosion is a yardstick of the possible loss of productivity of the soil associated with exploitation carried out with no regard for conservationist measures. This indicator is composed of a series of physical variables, the chief examples of which are relief, vegetation, severity of climate, morphological stability, water retention capacity,etc.

(*) For further details see "Identificação, Caracterização Ambiental e Potencial Agrícola de Zonas Prioritárias para o Desenvolvimento Rural" (Identification, Environmental Characterization and Agricultural Potential of Priority Zones for Rural Development), Roberto Sanchez, EDIBAP, 1980.

Finally, the impediments to mechanization interpret the physical qualities of the land in relation to the possible use of agricultural machinery and tools. The main characteristics considered in the indicator are the form and gradient of the slopes, natural drainage, surface stoniness and rockiness, and the depth, texture and clay type of the soil.

Each of these indicators may assume three values (low, medium and high), which are subsequently synthesized (*) by means of a standard methodology (**) that permits the identification of agroecological units which, in their turn, are associated with specific productive uses.

The evaluation of the aptitude of the land was carried out for what is termed "level of developed management". This level of management is characterized by the intensive application of capital, land management technology and measures for the improvement and conservation of the quality of the land.

The system of classification defines six groups of aptitude. The first three groups (I,II and III) contain systems of use based on cultivation, and almost always combine pasture and forestry. Group IV identifies lands suitable for pasture. Group V comprises non-arable land that, owing to its supply of natural pasture, permits cattle-raising activities and also forestry. Group VI consists of land unsuited to agriculture that is usually found in morphologically fragile environments, subjected to external geodynamics of moderate to

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(*) Soil humidity is excluded from this form of measurement, being the result of a combination of three indicators of lack of water and three others of oxygen deficiency. This generates nine possible values.

(**) Group models and types of agricultural aptitude of land, developed by FAO/UNDP and adapted for Brazil by SUPLAN/EMBRAPA.

great intensity. This land requires rational management in order that the landscape, flora and fauna may be preserved. Table 6.1 contains a synthesis of the aptitude of the soils in the study area.

Once the suitability of the soils has been determined the next task is to establish the recommended uses for each group. To do this the land constituting indigenous reserves is deducted from the total surface area of each group, giving the total land area available for agriculture, cattle-raising and forestry. The second step consists in defining the areas devoted to forestry (Group VI) and the forest reserves in accordance with existing legislation.

The remaining surface area is subsequently disaggregated into three categories of use: crops, pasture and natural pasture.

The basic studies of natural resources made in the basin have established that to maintain the productivity of soils suited to crops a constant application of organic matter is required. Owing to the high cost of this operation, the rotation of crops and stock-breeding on artificial grassland is recommended. The frequency of the rotation varies according to soil quality. Thus, it is recommended that type I soils should be given over to crops for 5 years and then to planted pasture for a further 5 years. Type II soils should be devoted to agriculture for 4 years and subsequently to cattle-raising for 6 years and those of type III to the same activities for 1 and 9 years respectively. In this way the potential agricultural surface area is:

$$\text{(ENV-1)}\quad POTAGR(A) = \sum_{G=1}^{3} SOLO(G,A) * IROT\ (G)$$

TABLE 6.1

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

APTITUDE OF SOIL USE (KM^2)

PROGRAMME AREAS	APTITUDE GROUPS						TOTAL SURFACE
	I	II	III	IV	V	VI	
1) ALTO PARAGUAY	1691	5693	7432	1565	7136	4904	28421
2) CÁCERES	5984	6169	8123	1911	14542	3647	40376
3) CUIABÁ	272	6000	16061	3605	45048	5617	76603
4) RONDONÓPOLIS	3100	8185	8884	12138	10757	6799	49863
5) BARRA DO GARÇA	625	33105	28510	35410	79995	6105	183750
6) DIAMANTINO	19560	269162	41845	79207	55275	38600	503649
STATE OF MATO GROSSO	31232	328314	110855	133836	212753	65572	882662
7) ALTO TAQUARI	1442	3920	7089	13647	15251	5755	47104
8) CAMPO GRANDE	3487	7372	14982	7212	2669	1833	37555
9) BODOQUENA	3651	5287	12300	9187	9837	3851	44113
10) CORUMBÁ	486	2350	3565	6031	65139	2027	79598
11) TRÊS LAGOAS	6130	13525	35930	845	16850	1620	74900
12) DOURADOS	19435	24369	17043	1180	5963	1120	69110
STATE OF MATO GROSSO DO SUL	34631	56823	90909	38102	115709	16206	352380
TOTAL REGION	65863	385137	201764	171938	328462	81878	1235042

SOURCE: EDIBAP, 1980

Where:

POTAGR (A) = Potential agricultural surface area, programme area A

SOLO (G,A) = Soil, group G, programme area A

IROT (G) = Rotation index, group G soils. The values of IROT (G) are 0.5; 0.4; and 0.1 for type I, II and III soils respectively.

The potential agricultural surface area is introduced into the agricultural sector of the economic submodel as a limit on the expansion of crops in each programme area.

The potential surface area for planted pasture is made up of the proportion of type I, II and III soils not suitable for crops plus those type IV and V soils that present conditions favourable to this activity. These soils are added to the potential agricultural surface area in order to define an economic limit to both these activities, which is also utilized as a restriction in the agricultural sector of the model:

$$\text{(ENV-2)}\quad POTPPL(A) = \sum_{G=1}^{3} SOLO\ (G,A) * (1-IROT(G)) + \sum_{G=4}^{5} SOLO(G,A) * CPP(G)$$

$$\text{(ENV-3)}\quad POTAPP(A) = POTAGR(A) + POTPPL(A)$$

POTPPL(A) = Potential surface area for planted pasture, programme area A

CPP(G) = Coefficient indicating potentiality for planted pasture, soil type G.

POTAPP(A) = Potential surface area for agriculture and planted pasture, programme area A.

The soils suitable for natural pasture are obtained by subtracting the total surface area of type IV and V soils from that of the other uses specified above. For operational reasons a special equation for natural pasture was omitted , since the restrictions it implies were established by means of the maximum cattle stock that each programme area is able to support. The potential land uses established on the basis of this methodology are summarized in Table 6.2.

In order to calculate the cattle-raising potential of each programme area the potential surface areas for natural and planted pasture are multiplied by an animal capacity per hectare index. This index varies according to the soil groups and their recommended use. (See Table 6.3). The cattle raising potential is subsequently used in the corresponding sector of the model as a limit on the cattle stock of each programme area:

Thus we have:

$$\text{(ENV-4)}\quad GANPOT\ (A) = \sum_{G=1}^{3} SOLO\ (G,A) * (1-IROT\ (G)) * CAPP\ (G) +$$

$$\sum_{G=4}^{5} SOLO\ (G,A) * CPP(G) * CAPP\ (G) +$$

$$\sum_{G=4}^{5} SOLO\ (G,A) * (1 - CPP\ (G)) * CAPN\ (G).$$

Where: GANPOT (A) = Maximum supportable cattle stock, programme area A

CAPP (G) = Animal coefficient per hectare of planted pasture, soil type G

CAPN (G) = Animal coefficient per hectare of natural pasture, soil type G

TABLE 6.2

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

POTENTIAL SOIL USE (KM^2)

PROGRAMME AREAS	RECOMMENDED USES					TOTAL SURFACE AREA
	AGRICULTURE	PLANTED PASTURE	NATURAL PASTURE	FOREST RESERVES	INDIGENOUS RESERVES	
1) ALTO PARAGUAY	1915	6234	6767	7805	5700	28421
2) CÁCERES	5085	11751	10316	13224	-	40376
3) CUIABÁ	3160	14835	24230	34378	-	76603
4) RONDONÓPOLIS	4345	13200	13205	17563	1550	49863
5) BARRA DO GARÇA	6283	23404	98104	20988	34971	183750
6) DIAMANTINO	45913	98556	108218	81985	168977	503649
STATE OF MATO GROSSO	66701	167980	260840	175943	211198	882662
7) ALTO TAQUARI	2436	9633	24460	10575	-	47104
8) CAMPO GRANDE	5274	17164	8426	6691	-	37555
9) BODOQUENA	3868	13242	13195	8499	5309	44113
10) CORUMBÁ	1231	6605	56813	14949	-	79598
11) TRÊS LAGOAS	10231	34984	17450	12234	-	74900
12) DOURADOS	18395	31979	6880	11856	-	69110
STATE OF MATO GROSSO DO SUL	41436	113607	127224	64804	5309	352380
TOTAL REGION	108137	281587	388064	240747	216507	1235042

TABLE 6.3

ANIMAL COEFFICIENT PER HECTARE OF PASTURE

SOIL TYPE	PLANTED PASTURE	NATURAL PASTURE
I	1,8	-
II	1,3	-
III	1,2	-
IV	1,1	0,28
V	1,0	0,25

SOURCE: EDIBAP, 1980

6.2 THE PHYSICAL SECTOR

This part of the physical and environmental submodel is based on the assumption that decisions on the location of the economic and social infrastructure condition the future spatial behaviour of the regional system.

The investments in infrastructure are intended to pass particular thresholds considered vital for the expansion of the socio-economic system in question. Of these, the ones that most strongly influence the spatial structure of the system are those relating to the extension and amelioration of the transport network, power supplies, and those designed to increase the region's ability to meet its basic social needs such as housing, health and education.

Investments in transport and energy tend, on the one hand, to extend the levels of activity each area is able to support and, on the other, to incorporate new areas into the regional system. Investments in social infrastructure for their part tend to improve the living conditions of the population and to reduce the inequalities in living standards found amongst the different areas of the regional system.

Each of these investments establishes definite patterns of human settlement, thereby defining the spatial dimension of a regional development strategy.

As is natural, the model incorporates only those variables over which the development plan assumes some kind of control on the part of the relevant authorities. For this reason investments in energy and housing are excluded from the model.

In the case of energy two fundamental activities are identified, the production of alcohol to replace petroleum and the supply of electric power. Alcohol production is being developed within the framework of a national plan that assigns specific goals and loans to the study area. These goals are explicitly incorporated into the agricultural (surface areas devoted to sugar cane) and industrial (export industry) sectors, and it would consequently be superfluous to incorporate them into this sector of the model.

The situation is different with regard to electric power. Decisions involving significant extensions of both generating capacity and long-distance transmission lines are taken centrally within the sphere of the Federal Government and are adopted not only on the grounds of regionally inspired antecedents but also in terms of a national energy strategy.

On the other hand, the program of the Ministry of Mines and Energy provides for the extension of transmission lines to meet the increases in short-term demand (1987). In the medium term the construction of the Manso Power Station has been decided upon with a view to increasing energy supplies in the State of Mato Grosso, which in principle will solve the problem until 1993.

The building of a power station at Corumbá in the State of Mato Grosso do Sul is under study.

Owing to the fact that the projects to be implemented were already practically defined and the fact that the decisions on their financing fall within the jurisdiction of federal government agencies it was considered preferable to exclude this sector from the model.

The housing sector was studied by EDIBAP only in terms of diagnosis, and its proposals are therefore of a general character excluding the identification of specific investments.

It can be inferred from the above that the physical sector of the model deals only with investments in health, education and transport.

6.2.1 Health

In the case of the health sector the most serious problems of the region concern the scanty cover provided by the health services, particularly in relation to the rural population, which is scattered out over very extensive zones. For this reason official policies postulate the territorial expansion of simplified schemes of health care as a fundamental goal.

The need to strengthen the structure of the more complex health services that should exist in the main urban centres is also recognized. This goal, however, is not a first priority for two reasons: not only does private medical practice play an important role in providing this type of service, but also the deficiencies in treatment at this level are not so serious as those found at the level of primary health care.

The policy of territorial expansion of the health services distinguishes four levels of health care in addition to the services provided by specialist hospitals. These levels are spatially distributed according to the politico-administrative structure. This structure is periodically adjusted in accordance with the growth of the population, which guarantees the maintenance of a certain proportionality between the volume and quality of health services and the population.

The most rudimentary level of health care is provided by community workers who, duly trained and supervised, are expected to perform immunizations, notify outbreaks of disease, gather information and undertake activities in the fields of health education, improvement of the environment, basic sanitation, etc. Their action is directed at the dispersed rural villages and small settlements.

The level immediately above this is that of the Health Post situated in the administrative centres of each district and intended to serve a population of between two and three thousand. The post is run by two auxiliaries, its activity is centred on basic primary health care and constitutes a means of access to more specialized services.

In the administrative centre of the municipalities is located the Health Centre which, in addition to providing primary health care, is equipped to give more complex forms of treatment and possesses a laboratory for clinical analyses, a radiology department and facilities for dental treatment, etc. The Health Centre supervises the activities of the municipal health posts and is staffed with one general practitioner, one dentist, four auxiliaries and three assistants.

The health unit of greatest complexity within the simplified health system is the Mixed Unit, which is located in the largest urban centre of each programme area. It performs the same activities as the Health Centre and, in addition, is able to admit patients for treatment (up to 50 beds). Its functions include the provision of full treatment in the basic specialities, appropriate treatment in emergencies and strategic specialities, public health activities, and the training and supervision of human resources.

As is to be expected, the implementation of a system like this calls for the simultaneous creation of a network of health units and the strengthening of the institutions responsible for their operation. In this respect the training of qualified staff is the critical element.

The simulation model is concerned with the quantification of the physical investments needed to ensure a complete coverage of the service in accordance with standards described above and to determine their location. The normal operating costs of the system must be included in the current budget of the corresponding state departments of health, for which reason their determination is beyond the limits of the model. In this way the shortage of health posts is obtained by comparing the number of districts in each programme area with the existing quantity of posts. In the case of the health centres the comparison is made between the existing number of centres and the number of municipalities that make up each programme area and a similar procedure is applied with the mixed units. Thus we have:

(PHY-1) DEFPS(A,T) = NDISTR(A,T) - STPS(A,T-1)
(PHY-2) DEFCS(A,T) = NMUNIC(A,T) - STCS(A,T-1)
(PHY-3) DEFUM(A,T) = 1-STUM(A,T-1) (*)

Where

DEFPS(A,T) = Shortage of health posts, programme area A, Year T
DEFCS(A,T) = Shortage of health centres, programme area A, Year T
DEFUM(T) = Shortage of mixed units, Year T
NDISTR(A,T) = Number of districts, programme area A, Year T
NMUNIC(A,T) = Number of municipalities, programme area A, Year T
STPS(A,T-1) = Number of existing health posts, programme area A, Year T
STCS(A,T-1) = Number of existing health centres, programme area A, Year T
STUM(T-1) = Number of existing mixed units, Year T-1

Once the shortages of the health units have been quantified the time required for their elimination and the priorities for the building of new units (location and type of unit) should be defined. This is obviously a political decision that must be made, bearing in mind the available financial resources of the bodies in question. For the purposes

(*) Since one mixed unit is postulated per programme area, STUM(A,T) may have the value 0 or 1.

of the model it is assumed that the number, type and location of the units to be built are defined exogenously.

(PHY-4) STPS(A,T) = STPS(A,T-1) + POSTO(A,T)

(PHY-5) STCS(A,T) = STCS(A,T-1) + CENTR(A,T)

(PHY-6) STUM(A,T) = STUM(A,T-1) + UMIX(A,T)

POSTO(A,T) = Number of health posts to be built, programme area A, Year T (OBJECTIVE)

CENTR(A,T) = Number of health centres to be built, programme area A, Year T (OBJECTIVE)

UMIX(A,T) = Mixed units to be built, programme area A, Year T (OBJECTIVE)

The quantity of investments is obtained by multiplying the units to be built by the estimated unit costs.

(PHY-7) INVSA(A,T) = POSTO(A,T) * COSPO + CENTR(A,T) * COSCE + UMIX(A,T) * COSUM

COSPO = Unit cost, health post

COSCE = Unit cost, health centre

COSUM = Unit cost, mixed unit

INVSA(A,T) = Total investments, construction of health units, programme area A, Year T.

6.2.2 Education

The region has serious educational shortcomings, resulting in a high incidence of illiteracy and a low level of formal education on the part of the literate population. This situation is the result of the insufficient development of education services, which at present are characterized by a lack of facilities and by serious deficiencies in the quality of the services provided.

The situation is significantly more serious in the rural zones, where the rate of school attendance in the first year of primary education represents only 39% of the population of school age (90% in urban areas). The diagnosis also reveals that the problems of the State of Mato Grosso are more acute than those of the State of Mato Grosso do Sul.

The primary education network is insufficient to cater for the whole of the school age population and has high rates of truancy and of pupils repeating a year, in addition to a marked distortion in terms of age/course (only 17% of those enrolled in primary education are of the appropriate age).

Secondary education in the region is practically confined to the urban areas of the municipalities. Even so, not all municipalities possess secondary schools. Thus, the number of places in secondary education in the region is limited, which explains why, according to 1970 data, only a small part of the population who did attend school completed the secondary course.

The qualifications of the teaching staff in the region are, in general, low. According to 1974 data, only 25.9% of teachers had undergone teacher training and only 15.2% had completed a university level course. In rural schools the teaching staff was even less qualified, for only about 6% of the teachers had completed a teacher training course.

More recent estimates, still to be confirmed, seem to indicate that educational standards in the region had improved markedly by the year 1980. In all events there is a clear need to widen the opportunities of access to education, to improve the school's ability to retain their pupils and to raise significantly the quality of teaching. To this end EDIBAP proposes a series of measures designed to widen the coverage of the education system and improve its standards.

As in the health sector the model deals with the quantification of the shortage of schools and the investments needed to eliminate it in accordance with the standards fixed for the region.

Thus, it is held that the need for schools in each programme area is equal to the school age population multiplied by a standard of pupils per establishment. Given that the aforementioned standard is different for rural and urban zones (the low rural population density requires the creation of small educational establishments in order to facilitate access to them), the model determines the requirements of both zones independently.

$$\text{(PHY-8)}\quad REQESU(A,T) = \sum_{S=1}^{2} \sum_{E=2}^{3} POPU(S,E,A,T) * CESCU$$

$$\text{(PHY-9)}\quad REQESR(A,T) = \sum_{S=1}^{2} \sum_{E=2}^{3} POPR(S,E,A;T) * CESCR$$

REQESU(A,T) = Need for schools, urban zones, programme area A, Year T

REQESR(A,T) = Need for schools, rural zones, programme area A, Year T

CESU = Standard of pupils per school, urban zones (OBJECTIVE)

CESR = Standard of pupils per school, rural zones (OBJECTIVE)

The shortage of schools is obtained by subtracting the number of existing schools the previous year from the required number determined above.

(PHY-10) DEFESU(A,T) = REQESU (A,T) - STESU (A,T-1)

(PHY-11) DEFESR(A,T) = REQESR (A,T) - STESR (A,T-1)

DEFESU(A,T) = shortage of schools, urban zones, programme area A, Year T

DEFESR(A,T) = shortage of schools, rural zones, programme area A, Year T

STESU(A,T-1)= existing schools, urban zones, programme area A, Year T-1

STESR(A,T-1)= existing schools, rural zones,programme area A, Year T-1

The schools to be built and their location reflect the goals of education policy. As such these goals are defined exogenously and then introduced into the model.

(PHY-12) STESU(A,T) = STESU(A,T-1) + ESCU(A,T)

(PHY-13) STESR(A,T) = STESR(A,T-1) + ESCR(A,T)

ESCU(A,T) = number of schools to be built, urban zones, programme area A, Year T (OBJECTIVE)

ESCR(A,T) = number of schools to be built, rural zones, programme area A, Year T (OBJECTIVE)

The investments entailed by the pursuit of the goals are determined by multiplying the number of schools to be built by their respective unit costs.

(PHY-14) INVED(A,T) = ESCU(A,T)*COSEU + ESCR(A,T)*COSER

INVED(A,T) = total investments, construction of schools , programme area A, Year T

COSEU = unit cost, urban-type school

COSER = unit cost, rural-type school

6.2.3 Transport

As mentioned above the region under study has low population density and has ample scope for incorporating new areas into production. This means that there is great flexibility for designing the projects of physical infrastructure that will condition its future spatial structure and behaviour.

Since the transport network is one of the elements that most decisively affect the spatial structure of a regional system, special care was taken to define a particular sector of the simulation model for studying the economic effects to be expected in the region as a consequence of the improvements in the road network proposed by EDIBAP.

The studies carried out in the Upper Paraguay River Basin led to the conclusion that the major deficiency in the regional road network was the lack of rural roads (*) able to support permanent traffic. Since this situation also constitutes a limiting factor to agricultural development, the study of transport projects was designed specifically to meet the requirements of roads in rural areas. Therefore, the transport sector of the model was oriented to the evaluation of the impact of such investment projects.

In conceptual terms there are two basic approaches for appraising road transport projects. They are the "road users' savings" and the "producer surplus" methods which utilize different procedures for quantifying the benefits associated with the project. A brief characterization of both approaches is presented below based on the main findings of the report of the Department of Transport of the World Bank (CARNEMARK, C. et.al., 1976). The road users' savings method, or demand for transport approach, determines a demand

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(*) Rural roads are defined as low traffic roads in agricultural areas.

for transport function and then quantifies the reduction in the operational costs of vehicles derived from specific investments (road improvements, construction of a new road,etc.) and estimates its effects on the total demand for transport. The benefits of the project are measured as the difference of total expenditure on transport in current conditions and the expected expenditure after the project's implementation.

The producer surplus method for its part tries to measure the benefits attributed to the project in terms of the increase in the level of economic activity it may induce.The benefits are quantified as the increase in the producers' benefits resulting from the road improvement, assuming that all reductions in transport costs generated by the project are transferred to producers in the form of increments of received prices and reductions in input costs.

The first method is recommended when normal traffic (or its expected growth) is high and the economies in transport costs constitute a reasonable measure of the project's benefits. This is the case with already developed regions where road improvements are not likely to induce further growth but to reduce overall costs of transportation. The producer surplus method is most applicable to underdeveloped regions where current traffic is low and where it is expected that the implementation of specific development programmes would induce an increased level of economic activity. In these circumstances transport savings, as regards actual traffic, are negligible and analysis must concentrate on the induced effects of the road project, e.g., the opening of a new agricultural area, the complementing of set of programmed investment projects, etc.

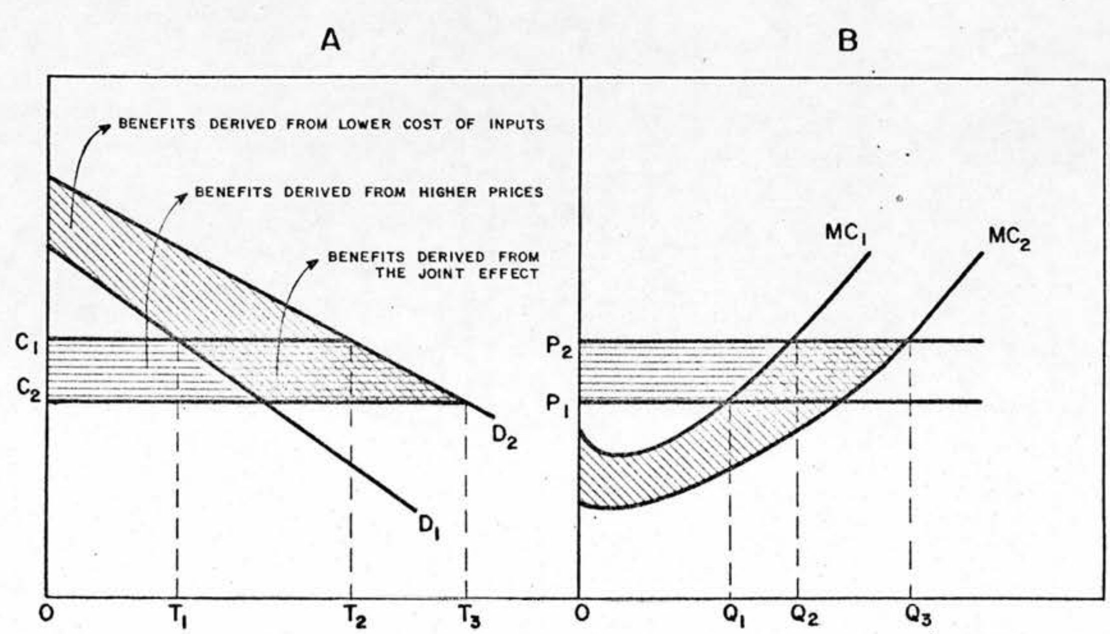
For a better understanding of these methods a schematic view of the way the benefits of a project are quantified by both approaches is presented below. An underdeveloped rural area is assumed where the road under study constitutes the only way to transport agricultural produce from farms to the market and inputs for that produce in the opposite direction. It is also assumed that all reductions in transport costs are transferred to farmers (as higher prices for agricultural production and lower costs of inputs)who devote these additional resources to increasing their level of activity.

The demand for transport approach starts by determining the volume of traffic under normal conditions. Thus, before any improvement in the road total demand for transport is represented by curve Dl (Fig. .1A) and the cost of transporting one ton of agricultural produce (or inputs) per kilometre is Cl. This defines the current volume of transported goods Tl.

The improvement in the road resulting from the implementation of the project under consideration, reduces the operational cost of vehicles, which leads to lower transport costs. According to the assumptions made, the induced reduction in input cost stimulates a greater agricultural production, which in turn generates an increased demand for transport for this activity. This effect is represented by the movement of the demand curve from Dl to D2. If measured in terms of the original cost of transport (Cl) the benefits derived from the lower cost of inputs are represented by the area between Dl and D2 and above Cl, T2 represents the new volume of transport.

Figure 6.1

SCHEMATIC VIEW OF THE DEMAND OF TRANSPORT AND PRODUCER SURPLUS APPROACHES



As established, the project also transfers the transport savings to farmers by proportionally increasing the price of their produce (C1 - C2).

These higher prices stimulate a further increase in production and consequently in the demand for transport.The final volume of transported goods is T3 and the benefits for farmers derived from higher prices are represented by the area to the left of D1 and between C1 and C2. The area between D1 - D2 and C1 - C2 corresponds to the benefits of the project attributable to the joint effects of input cost reduction and higher prices. Obviously, the total benefits of the project are the sum of these three effects. The producer surplus method, for its part, starts by determining the normal level of activity before the improvement in the road.

As shown in Fig. 6.1.B, normal production (Q1) corresponds to the point where marginal cost function (MC1) equals market price (P1). In this situation the producer surplus is the difference between the total income of producers (OP1*OQ1) minus production costs (area under MC1, between O and Q1).

As mentioned above the project increases the producer surplus both by reducing input costs and by increasing the prices received by farmers.

Input cost reduction entails a decrease in total production costs at any level of activity. This is represented by the movement of the marginal cost function from MC1 to MC2.Higher prices, in their turn, lead to a new price line P2.The new level of activity is Q3 and the producer surplus corresponds to the area between P2 and MC2. The rise in the producer surplus induced by the project is composed of benefits derived from cheaper inputs (diagonally shaded area), benefits attributable to higher prices (horizontally shaded area) and the joint effects of cheaper inputs and higher prices (squared area).

Although both methods for appraising road projects lead to similar results, the selection of one rather than the other is largely conditioned by the socio economic context of the project and by the quality of available information. Since the study area has a low level of economic activity and has ample scope for incorporating new areas into agricultural production, the producer surplus approach was adopted as the conceptual framework of the transport sector of the model. The final form of the transport model resulted from the findings of a research programme carried out by GEIPOT (Brazilian Transport Planning Corporation), where the Upper Paraguay River Basin was utilized as a case study for testing an econometric model for assessing the impact of investments in rural roads. (*)

Such a model quantifies the benefits of a road project in terms of the increased agricultural production it induces in its area of influence. It is assumed that the value of agricultural production is a function of the amount of available land, its quality and its accessibility. Thus, the assessment of the project's impact is carried out by comparing the current level of agricultural production with that expected under the higher accessibility resulting from the proposed investment.

Relationships between the quantity and quality of available land and the value of agricultural production are perfectly obvious and can be regarded as defined by the technology utilized. However, the role of accessibility as an explanatory variable of such a function requires some comment.

Due to the special spatial behaviour of agriculture (space can be regarded as playing the role of a productive factor), transport costs constitute a decisive factor in determining

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(*) GEIPOT, Pesquisa sobre impacto de Rodovias Vecinais, (Research on the impact of local roads), Brasilia, 1981 the amount of land that can be economically devoted to production. Von Thünen's agricultural location theory explains the spatial distribution of production by defining the income from one unit of land as a function of distance (*):

$$R = E*(p-a) - E*f*k$$

Where

R= income from one unit of land

E= land productivity

p= market price per unit of agricultural produce

a= production cost per unit of produce

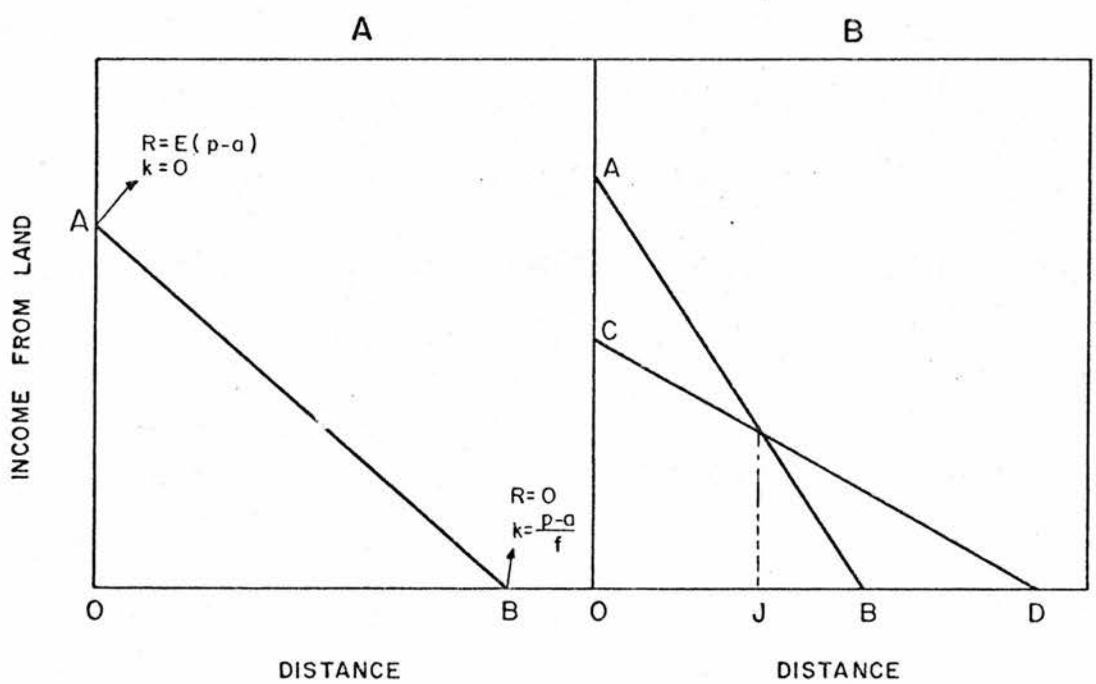
f= transport cost

k= distance

The graphical representation of this function (Fig.6.2.A) shows that in the market place (k=0) the income from one unit of land equals the productivity (E) multiplied by net income per unit (p-a). Because of the negative slope of the function (-E*f), the income per hectare decreases as production moves far from the market and becomes null when $k=\frac{p-a}{f}$. This means that no production can economically take

Figure 6.2

VON THÜNEN'S INCOME FROM LAND FUNCTION



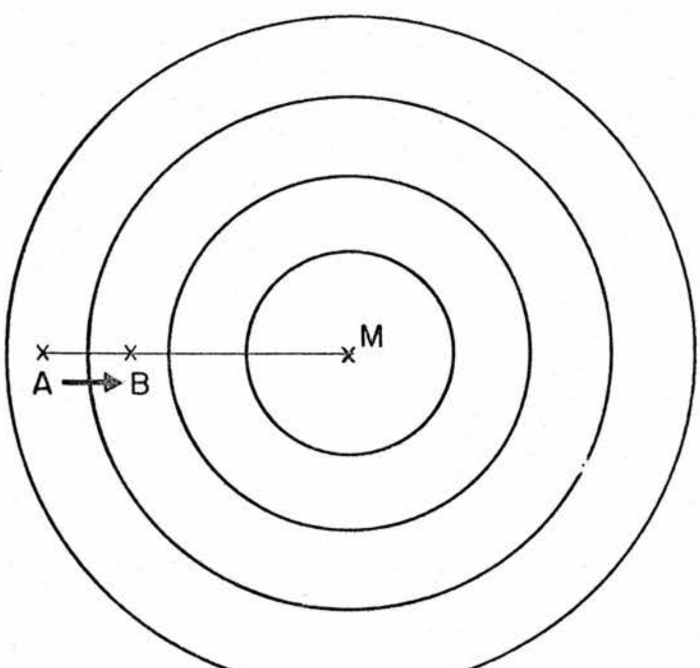
(*) A good analysis of Von Thünen's work can be found in MELCHIOR, E., 1975 place at a distance from the market higher than OB, since beyond this point the income from the land becomes negative.

When a second product is incorporated into the analysis selection between productive options in each location is made according to the principle of income maximization, leading to the definition of the spatial distribution of its production. The income function of product I is represented by the line AB (Fig. 6.2.B) while line CD corresponds to the income function of product II.

For any piece of land located between 0 and J product I generates a higher income than product II. Therefore, the production of I will be preferred near the market and up to the distance at which its income is equal to its marginal opportunity cost (J). Beyond this point product II becomes preferable. In spatial terms this means that the circular area of ratio 0J is devoted to the production of I and the ring of length JD to product II. (*)

Figure 6.3

VON THÜNEN'S AGRICULTURAL LOCATION SCHEME



(*) Melchior establishes that this analysis is correct inso far as the following conditions are met:
i) $E(I)*(P(I)-a(I) > E(II)*(P(II)-a(II) > 0$, and
ii) K_I (for $R=0$) $> K_{II}$ (for $R=0$) (MELCHIOR, 1975; p.45)

If the parameters of the income function for a number of products are known, the optimum land use pattern can be established. This will situate each crop on a concentric ring around the market, as shown in Fig. 6.3.

Although this analysis led Von Thünen to some unprecise generalizations (see CORAGGIO, 1973; and MELCHIOR, 1975), it constitutes a highly simplified but valid attempt to explain land income differentials attributable to the spatial location of agricultural production units.

For the purposes of our model reductions in both transport costs and travel time resulting from the implementation of a road project are to be seen as having the same effect as moving a production unit to a ring closer to the market. This is shown by Fig. 6.3 where an improvement in the road connecting point A with the market (M), reduces transport costs and in this way makes it possible to produce in A certain goods that without such a project could not be produced farther from the market than B. Obviously, this reduction in transport costs leads to a higher income per hectare at point A and at all farms located within the area of influence of the road. Thus, the inclusion of accessibility as an independent variable of the rural production function of the model was the procedure adopted to define a relationship between spatial variables and economic ones.

The transport sector of the model was calibrated by means of OLSQ on cross-section data using a sample of 25 municipalities.

The value of agricultural production (VAP) was measured in cruzeiros (of April 1980) and includes the results of agricultural and cattle-raising activities and also the production of the rural industry. As such this dependent variable represents the total production of non urban areas of each spatial unit, excluding extractive activities (namely mining and forestry) which can not be explained properly by the independent variables selected. Accessibility (ACC) represents the locational position of the spatial unit of analysis (municipality) with regard to the system of urban centres. It was measured in terms of the reciprocal of travel time between the main town of the municipality and the other urban centres. This was a quite complex procedure which involved some operational assumptions. Firstly, a hierarchy of urban centres was defined on the basis of the findings of a recent study carried out at the national level (IBGE, 1980) that defined the area of influence of 1416 cities throughout Brazil. This provides a basic hierarchy for defining the transport route from the most remote rural areas in the region to the national metropolitan centre of Sao Paulo. Secondly, the road network was identified by distinguishing four types of roads according to their quality (minor, earth, stabilized and paved) each of which was associated with an average travel speed.

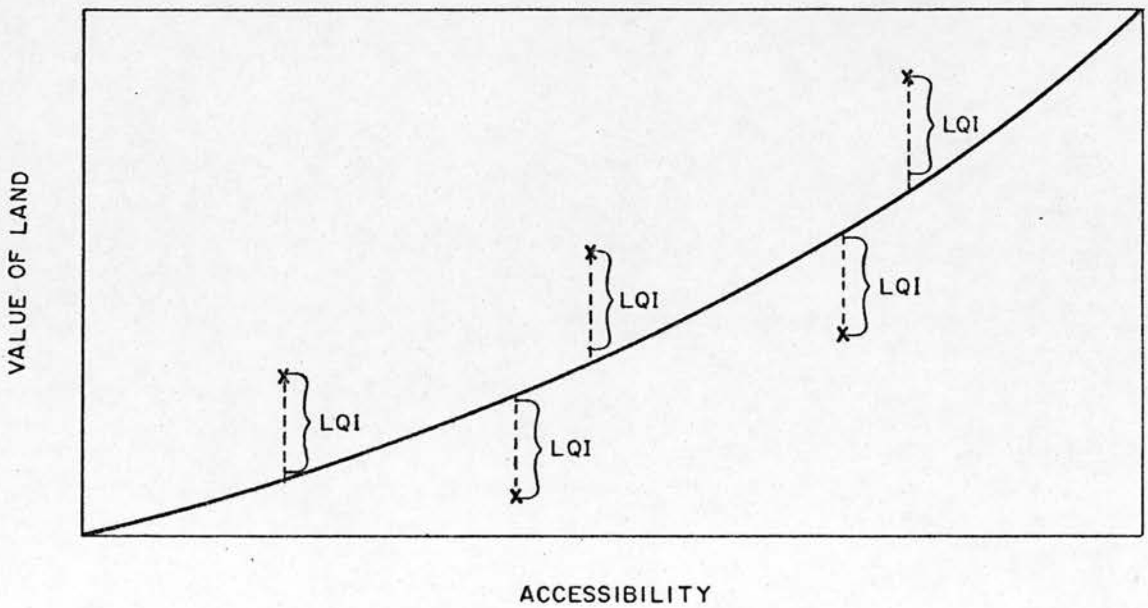
Thirdly, all distances in the road network were measured and then transformed into travel times through the average speed for each type of road and expressed as an accessibility index (1/travel time - expressed in minutes). Finally accessibility indexes were classified in three categories according to the urban centre to which they referred. They are: a) accessibility to the metropolitan centre of Sao Paulo (ACC 1), b) accessibility to the State capitals (ACC 2; Cuiaba in Mato Grosso and Campo Grande in Mato Grosso do Sul) and c) accessibility to the main town of each programme area (ACC 3). Each of these sets of accessibility indexes was used independently for calibrating the model. The accessibility of municipalities to the main town of programme areas was disregarded because it yielded poor levels of significance.

The second independent variable, land available for agriculture (LAN), represents the amount of land able to support agriculture and cattle-related activities, and was obtained from the agricultural census.

The last explanatory variable, land quality index (LQI) is a measure of land productivity. Since a high incidence of this variable was expected in the explanation of rural production, it was simultaneously studied from two different points of view. On the one hand, starting from the studies of natural resources carried out by EDIBAP (see Section 6.1), potential agricultural production (including cattle-raising) was determined and expressed as an index of the potential productivity of land. On the other hand, an indirect methodology developed by GEIPOT was tried and finally adopted because it provided better statistical results. This methodology assumes that the value of land is basically determined by its potential productivity and its location with regard to the urban system. The agricultural census provides the value of land (excluding all investments and improvements); thus LQI was obtained as the residual of the regression between land value (LVA, dependent variable) and accessibility determined as explained above (Fig. 6.4 explains the conception of LQI utilized).

Figure 6.4

CONCEPT OF LAND QUALITY INDEX (LQI)



OLSQ performed on a logarithmic version of this function provided the following results.

$$\text{(PHY-15)}\ LLVA(M) = \underset{(4.71)}{17.845} + \underset{(4.70)}{2.546}\ LACC1\ (M)$$

Where

LLVA(M) = log. land value, municipality M

LACC1 (M)=log. accessibility index municipality M with regard to the metropolitan centre of Sao Paulo

$R^2 = 0.49$

$F = 22.10$

Thus, the part of the land value not explained by this regression (51% of land value) is considered as the land quality index and utilized as an independent variable of the rural production function. Thus, LQI is defined with the following equation:

$$\text{(PHY-15*)}\ LQI(M) = LVA(M) - 56,23,194*(ACC1(M))^{2.546}$$

Once the variables were quantified, a regression analysis was carried out for determining the final form of the rural production function. Since there were many possible combinations of independent variables, (three acessibility indexes) the stepwise procedure was utilized and the following results were obtained

$$\text{(PHY-16)}\ LVAP(M) = \underset{(0.53)}{0.788} + \underset{(7.75)}{0.845}\ LLAN(M) + \underset{(5.74)}{0.893}\ LLQI(M) + \underset{(2.43)}{0.261}\ LACC2(M)$$

Where

LVAP(M) = log. value of agricultural production, municipality M

LLAN(M) = log. land available for agriculture, municipality M

LLQI(M) = log. land quality index, municipality M

LACC2(M)= log. accessibility index with regard to the state capitals.

$R^2 = 0.79$
$F = 25.81$

Thus the function to be included in the model is

$$(\text{PHY-16*})\ VAP(M) = 2.199 * (LAN(M))^{0.845} * (LQI(M))^{0.893} * (ACC2(M))^{0.261}$$

A sample of the type of results provided by this version of the transport sector of the model is presented in Table 6.4.

Since the transport sector of the model thus designed constitutes a tool for giving priority to road projects, it is different in nature and purpose to the other sectors of the model. For this reason it is to be run independently of the simulation of the general model and its results are to be utilized as a criterion for selecting the combination of road projects to be financed by the funds granted for this purpose and also used for determining the level of activity of civil construction (see Section 5.5). The particular character of the transport sector and the static nature of the environmental sector (which is used only for determining environmental constraints on the utilization of natural resources for economic purposes), mean that it would be pointless to design a flowchart for them.

Nevertheless, in order to give an adequate treatment to the health and education sectors, they are included in the flowchart of the composite model (see Chapter 7).

TABLE 6.4

SAMPLE OF THE RESULTS OF THE TRANSPORT SECTOR OF THE MODEL

	ROAD		EXTENSION	QUALITY OF ROAD		TRAVEL TIME (MIN)		INDUCED INCREASE OF RURAL PRODUCTION (*)	% OF CURRENT PRODUCT.	PROD KM (*)
	FROM	TO	(KM)	BEFORE IMPROVEMENT	AFTER IMPROVEMENT	BEFORE IMPROV.	AFTER IMPROV.			
MATO GROSSO	ACORIZAL	CUIABA	56	ST	AS	67	42	679.6	12.76	12.1
	N.S. LIVRAMENTO	CUIABA	40	ST	AS	48	30	1,265.9	13.44	31.6
	POXOREO	RONDONOPOLIS	87	ST	AS	104	65	3,434.1	12.40	39.5
	DOM AQUINO	BR-163	30	ST	AS	36	23	816.5	4.68	27.2
	ITIQUIRA	RONDONOPOLIS	124	ST/AS	AS	113	93	777.0	5.22	17.7
	ARENAPOLIS	CUIABA	168	ST	AS	202	126	4,982.7	13.32	29.7
	BARRA DO BUGRES	CUIABA	150	ST	AS	180	113	4,981.7	13.13	33.2
MATO GROSSO DO SUL	ANTONIO JOAO	RIO BRILHANTE	260	ST	AS	312	195	30,047.0	16.42	115.6
	CARACOL	ANASTACIO	311	ST	AS	373	233	3,637.1	6.27	11.7
	MIRANDA	AQUIDAUANA	68	ST	AS	82	50	421.2	3.53	6.2
	RIO NEGRO	CAMPO GRANDE	137	ST/AS	AS	158	95	4,393.2	11.95	34.6
	SIDROLANDIA	BR-060	76	EA/ST/AS	AS	89	57	5,951.2	12.35	165.3
	PEDRO GOMES	BR-163	21	EA	AS	43	16	387.2	3.02	18.4
	CAMAPUA	BR-163	40	ST	AS	48	30	793.1	3.69	18.8

(*) THOUSAND CRUZEIROS OF 1975. AS = ASPHALT; ST = STABILIZED; EA = EARTH.

CHAPTER SEVEN

THE COMPOSITE MODEL

7. THE COMPOSITE MODEL

The composite model is the integrating framework of the partial submodels. As such, its function is that of compatibilizing the aforementioned submodels in such a way that, taken together, they lead to a coherent view of the functioning of the regional socio-economic system. In addition, it provides certain indices for assessing the impact that would result from the implementation of the projects and specific actions entailed by the simulated strategies, as well as the economic feasibility of the strategies in question. Accordingly, what is termed "composite model" is a methodological instance of the model that contains a series of operative norms for regulating the calculation sequence of the submodels, transferring partial results from one submodel to another and subsequently eliciting some results of a general nature. This methodological instance does not contain behavioural equations but it is the element controlling the general algorithm of the model.

In order to make this part of the simulation model easier to understand this chapter is divided into three sections. The first deals with aggregation of partial results, the second discusses the procedures used to determine the economic feasibility of the simulated strategies, and the third is devoted to a review of the problems involved in the operation of the model.

7.1 AGGREGATION OF PARTIAL RESULTS

The first stage in the integration of partial submodels entails the aggregation of sectorial estimates of product and employment for obtaining global results at the programme area level and also some indices about the behaviour of subregional economies. Global regional estimates are then determined by aggregation of these subregional variables.

Firstly the model determines employment generated in each programme area in both the rural and urban sectors.

Rural employment is obtained by adding permanent and temporary employment in the agricultural sector to that generated by stock-breeding.

Due to the form of calculation used, this total refers exclusively to direct employment generated by the above-mentioned activities. In order to obtain total employment in rural zones it is necessary to multiply these figures by a coefficient that takes into consideration indirect employment.

Thus we have:

(GRL-1) EMPLR(A,T)=[EMPAP(A,T)+EMPAT(A,T)+EMPEC(A,T)]*CEIND(T)

Where

EMPLR(A,T)=total rural employment,programme area A, Year T

EMPAP(A,T)=permanent employment in agriculture,programme area A, Year T

EMPAT(A,T)=temporary employment in agriculture,programme area A, Year T(*)

EMPEC(A,T)=employment in cattle-raising, programme area A, Year T

CEIND(T) =total employment/direct employment coefficient for the rural sector, Year T

(*) Temporary employment in agriculture is a measure of the number of persons exhibiting some form of underemployment. It is expressed as the number of equivalent jobs, which allows it to be added to permanent employment in order to determine total employment in agriculture.

Urban employment is obtained by adding the number of jobs in each of the economic sectors. In this case sectorial jobs were calculated as total employment, for which reason no subsequent adjustments are necessary. The total employment of each programme area is obviously the sum of the rural and urban totals.

(GRL-2) EMPLU(A,T)=EMIMA(A,T)+EMIMI(A,T)+EMIOU(A,T)+EMIEX(A,T)
EMCON(A,T)+EMCSE(A,T)+EMGOB(A,T)

(GRL-3) EMPTOT(A,T)=EMPLR(A,T)+EMPLU(A,T)

EMPLU(A,T)	=	total urban employment,programme area A,Year T
EMIMA(A,T)	=	employment in the timber industry,programme area A, Year T
EMIMI(A,T)	=	employment in the mining industry,programme area A, Year T
EMIEX(A,T)	=	employment in the export industry, programme area A, Year T
EMIOU(A,T)	=	employment in diverse industries, programme area A, Year T
EMCON(A,T)	=	employment in the building sector, programme area A, Year T
EMCSE(A,T)	=	employment in commerce and services,programme area A, Year T
EMGOB(A,T)	=	employment in the public sector,programme area A, Year T
EMPTOT(A,T)	=	total employment, programme area A, Year T

With these elements the growth rate of total employment per programme area and the proportion of total employment generated by the primary sector are calculated. Both elements constitute input for the demographic submodel in Year T+1.

(GRL-4) $$\mathrm{CREMP}(A,T) = \frac{\mathrm{EMPTOT}(A,T)}{\mathrm{EMPTOT}(A,T-1)} - 1$$

(GRL-5) $$\mathrm{PEP}(A,T) = \frac{\mathrm{EMPLR}(A,T)}{\mathrm{EMPTOT}(A,T)}$$

CREMP(A,T) = Growth rate of total employment, programme area A, Year T

PEP(A,T) = Percentage of primary employment, programme area A, Year T

In the employment sector of the model the demand for jobs is determined by applying an employment goal to the available labour force.

The formulation assumes that mobility of labour will lead to regional full employment if there is an equilibrium between labour supply and demand at the national level, or to an equitable distribution of a labour surplus (or shortage) in the case of structural imbalance.

This approach was adopted, especially in view of the high incidence of migration in the rate of population growth in the study area. Thus, the demographic submodel explains net migration rates as a function of the behaviour of employment. However, since relocation costs in Brazil are relatively high (mainly due to the vastness of the country) and also because of an imperfect labour market it can not be expected that migration alone will guarantee full employment in the region. In fact, it is found that some regions face severe unemployment problems while others suffer from a labour shortage. This obviously leads to important differentials in regional wages that remain for long periods.

In an earlier version of the model a special subroutine was created for adjusting the level of economic activity in order to ensure the pursuit of the employment goals. This constituted quite an elaborate process since it was necessary to recalculate the activity levels of all the programme areas and for every one of the years included in the simulation period.

This procedure was abandoned, as it frequently led to unviable strategies and also because it made it difficult to visualize the effect that the proposed strategies would normally produce. In these circumstances it was considered preferable to use indicators of the performance of each strategy in the generation of employment.

Thus, full employment is introduced into the composite model as a policy objective and the conditions for its achievement are defined by means of specific simulations.

In order to assess the performance of the strategy in this respect the expected rates of rural, urban and total unemployment are calculated and compared with the intended objectives. In the event of significant discrepancies between the two unemployment rates it is possible to perform simulations of the model in order to determine the additional amounts of sectorial investment needed for attaining the initial goals.

$$\text{(GRL-6)}\quad DESRUR(A,T) = 1 - \frac{EMPLR(A,T)}{REMPR(A,T)}$$

$$\text{(GRL-7)}\quad DESURB(A,T) = 1 - \frac{EMPLU(A,T)}{REMPU(A,T)}$$

$$\text{(GRL-8)}\quad DESTOT(A,T) = 1 - \frac{EMPTOT(A,T)}{REMPT(A,T)}$$

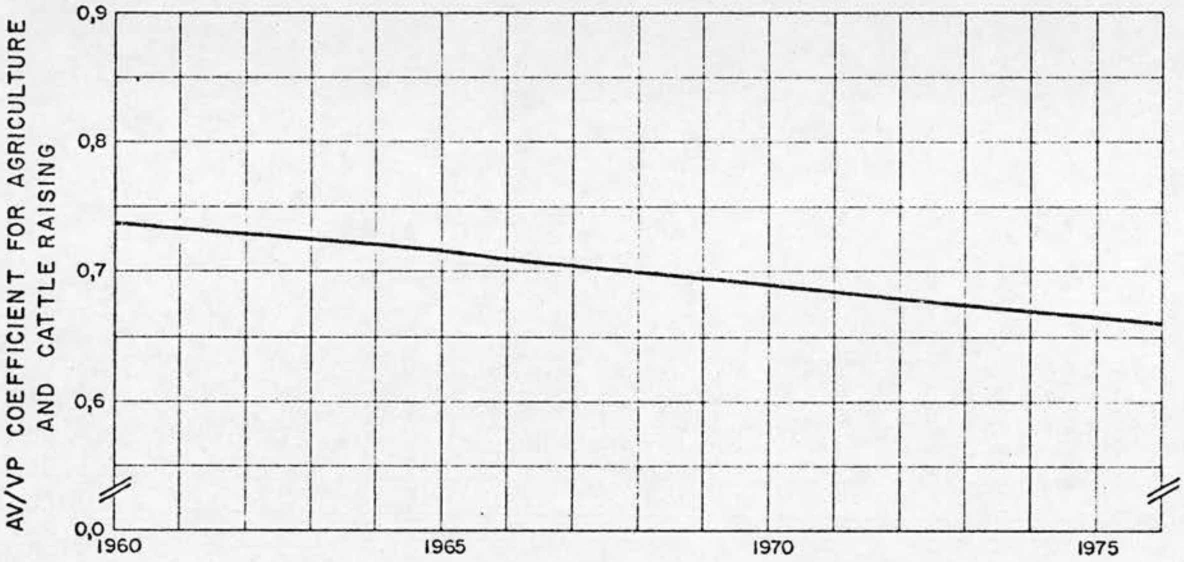
The next step consists of determining the rural, urban and total product and usual indicators of the evolution of the level of economic activity.

In the case of the agricultural and cattle-raising sectors the respective models determine the gross value of production and not its added value. In order to calculate the added value of these activities a coefficient relating both concepts is used. This coefficient, which is periodically calculated by the Getulio Vargas Foundation, shows a downward tendency in time. (See Fig. 7.1) (*)

(*) In spite of the availability of a coefficient for the whole of the cattle-raising sector it was considered preferable to use independent estimates for agriculture and cattle-raising. These estimates were obtained from the agricultural and cattle-raising projects developed by EDIBAP.

Figure 7.1

EVOLUTION OF THE ADDED VALUE-GROSS VALUE OF PRODUCTION COEFFICIENT FOR AGRICULTURE AND CATTLE-RAISING



SOURCE: Fundação Getúlio Vargas

As is argued in the agricultural sector of the model, a sizable part of the increase in land productivity is accounted for by rises in the quantity and quality of inputs per hectare of cultivated land. This means that the incidence of the inputs in the value of production increases with the rise in agricultural productivity and, as a result, the proportion represented by the added value of this sector falls. A similar pattern of behaviour is assumed in the case of the cattle raising sector, since the productivity of the land for pasture is dependent on the same factors as for crops and the productivity of the cattle herds is also enhanced through improvements of inputs.

In accordance with the above, the added value of agriculture and cattle-raising of each programme area is equal to the value of agricultural and cattle-raising production, multiplied by the respective added value/production value coefficient.

(GRL-9) PROAG(A,T) = VBPAG(A,T)*CVAG(T)

(GRL-10) PROPE(A,T) = VBPEC(A,T)*CVPE(T)

(GRL-11) PRORUR(A,T)= PROAG(A,T) + PROPE(A,T)

PROAG(A,T) = agricultural product,programme area A,Year T

PROPE(A,T) = cattle-raising product,programme area A,Year T

PRORUR(A,T) = rural product, programme area A, Year T

VBPAG(A,T) = gross value of agricultural production,programme area A, Year T

VBPEC(A,T) = gross value of cattle-raising production,programme area A, Year T

CVAG(T) = added agricultural value/gross value of agricultural production coefficient, Year T

CVAP(T) = added cattle-raising value/gross value of cattle raising production coefficient, Year T

The urban product is equal to the sum of the added value of the secondary and tertiary activities identified in the model. The total product of each programme area obviously corresponds to the sum of the urban and rural product.

(GRL-12)PROURB(A,T)=VAMAD(A,T)+VAMIN(A,T)+VAIEX(A,T)+VAIOU(A,T)
VACON(A,T)+VACSE(A,T)+VAGOB(A,T)

(GRL-13)PROREG(A,T)=PRORUR(A,T) + PROURB(A,T)

PROURB(A,T) = urban product,programme area A,Year T

VAMAD(A,T) = added value of timber industry,programme area A, Year T

VAMIN(A,T) = added value of mining industry,programme area A, Year T

VAIEX(A,T) = added value of export industry,programme area A, Year T

VAIOU(A,T) = added value of diverse industries,programme area A, Year T

VACON(A,T) = added value of civil construction,programme area A, Year T

VACSE(A,T) = added value of commerce and services, programme area A, Year T

VAGOB(A,T) = added value of public sector, programme area A, Year T

PROREG(A,T) = total product, programme area A, Year T

Once the level of total activity of each programme area is known the growth rate of added value and per capita product are calculated. These constitute traditional indicators for assessing the behaviour of an economic system that, in our case, allow an evaluation of the strategy's capacity to stimulate the economic growth of the area.

$$\text{(GRL-14)} \quad TXCREC(A,T) = \frac{PROREG(A,T)}{PROREG(A,T-1)} - 1$$

$$\text{(GRL-15)} \quad YPC(A,T) = \frac{PROREG(A,T)}{POP(A,T)}$$

TXCREC(A,T) = annual growth rate of product, programme area A, Year T

YPC(A,T) = per capita product, programme area A, Year T

7.2 ECONOMIC FEASIBILITY OF REGIONAL DEVELOPMENT STRATEGIES

In operational terms a development strategy can be defined as an internally coherent set of goals and objectives, together with a set of policies, investment projects and actions specifically designed to achieve them.

As such, the formulation of a development strategy entails the temporal and spatial ordering of an harmonious set of actions and investment projects, each of which requires a special allocation of resources.

It follows that the strategy is feasible in economic terms only if the resources necessary for the implementation of defined actions and projects are supplied in quantity and volume and at the moment and place required. Since thus defined strategies constitute a first approach to a subsequent more detailed development plan, their feasibility need only be measured in terms of the volume of resources required for each year of the forecasting period. Required resources are expressed as total investments implied by the strategy, while available resources are composed of internal savings, net inflow of capital from the rest of the country and public investment.

In our case required resources were divided into private investment requirements and public ones. The required amount of private investment was obtained by adding the net investment necessary to achieve the projected sectoral growth. Sectoral net investment results from applying the marginal capital - product ratio to the expected increase in each sector's output. These ratios were obtained from the investment projects formulated by EDIBAP for agriculture, cattle-raising and export industry. For the other sectors estimates made for the whole country were utilized. Thus we have:

$$
\begin{aligned}
\text{(GRL-16)}\quad \mathrm{PRIINV(T)} = \sum_{A=1}^{12} \Big[& \mathrm{(PROAG(A,T+1)-PROAG(A,T))*KPRAGR+} \\
& \mathrm{(PROPE(A,T+1)-PROPE(A,T))*KPRPEC+} \\
& \mathrm{(VAMAD(A,T+1)-VAMAD(A,T))*KPRMAD+} \\
& \mathrm{(VAMIN(A,T+1)-VAMIN(A,T))*KPRMIN+} \\
& \mathrm{(VAIEX(A,T+1)-VAIEX(A,T))*KPRIEX+} \\
& \mathrm{(VAIOU(A,T+1)-VAIEX(A,T))*KPRIOU+} \\
& \mathrm{(VACON(A,T+1)-VACON(A,T))*KPRCON+} \\
& \mathrm{(VACSE(A,T+1)-VACSE(A,T))*KPRCSE} \Big]
\end{aligned}
$$

Where

PRIINV(T) = required amount of private investment, Year T
KPRAGR = capital-product ratio, agriculture
KPRPEC = capital-product ratio, cattle-raising
KPRMAD = capital-product ratio, timber industry
KPRMIN = capital-product ratio, mining
KPRIEX = capital-product ratio, export industry

KPRIOU = capital-product ratio, diverse industries
KPRCON = capital-product ratio, civil constuction
KPRCSE = capital-product ratio, commerce and services

The public investment requirement, for its part, is composed of the sum of resources demanded by education, health and transport, plus the investment required by the increase in normal government activities.

$$\text{(GRL-17)}\quad PUBINV(T) = \sum_{A=1}^{12} \Big[(INVSA(A,T)+INVED(A,T)+INVTR(A,T)+ (VAGOB(A,T+1)-VAGOB(A,T))*KPRGOB\Big]$$

PUBINV(T) = required amount of public investment, Year T
KPRGOB = capital-product ratio, Government

For determining the Regional savings' capacity to finance these investment requirements two ways were explored. The first consisted of determining the total investment resources the region can generate internally and attract from the rest of the country, both from private and public sources. Such an investment capacity, if compared with the investment requirements resulting from (GRL-16) and (GRL-17), determines the extent to which the processed strategy is economically feasible.

Interregional movements of financial capital are very difficult to estimate since they are a function of the relative interregional differences in the rates of return and of the cost of overcoming the spatial friction. Thus the amount of private resources that may be attracted from other regions must be determined exogenously.

Public investment, for its part, is determined and allocated among regions at the national level; thus it should also be considered as an exogenous parameter for determining the regional investment capacity.

Because of the difficulties implied by such estimates this procedure was abandoned.

The second way consisted of determining the conditions for making the strategy feasible rather than producing a measure of its economic feasibility. This approach is more consistent with the procedural framework for regional planning proposed in chapters 1 and 2.

In fact, to the extent that regional planning should be a very flexible tool for increasing the bargaining power of regions vis-ã-vis the Central Government or extraregional firms it is more important for the authorities of a particular region to have a basic strategy for negotiating additional resources with the Central Government or specific investments with national firms than to have a modest and feasible development strategy.

This approach is also consistent with Brazilian negotiation practices. As mentioned above, the most important instruments used in Brazil for promoting regional development are the capital-supply type measures, such as public investment, federal transfers to specific activities, tax incentives for investment in selected regions, subsidized credits,etc. (See section 3.2) It follows that the amount of resources a region needs for making a development strategy feasible is not defined before the strategy is ready but is a matter of negotiation. Obviously, the bargaining capacity of a region increases to the extent that clear strategies and specific projects for investment are at hand.

Thus, the model only determines the investment resources the region is able to generate internally, leaving the rest to be negotiated. In this way the model becomes easier to manipulate and better suited to regional planning needs.

Internal savings are then obtained by multiplying the income generated in the region by the average propensity to save.

Because of lack of information this parameter was calculated from (available) regional accounts for 1970 and 1975 and was assumed to be constant for the whole forecasting period.

$$\text{(GRL-18) RESAV(T)} = \sum_{A=1}^{12} \text{PROREG(A,T)*SAVPR}$$

(GRL-19) SAVGAP(T)= PRIINV(T) - RESAV(T)

RESAV(T) = regional savings, Year T

SAVPR = average propensity to save

SAVGAP(T)= private savings gap, Year T

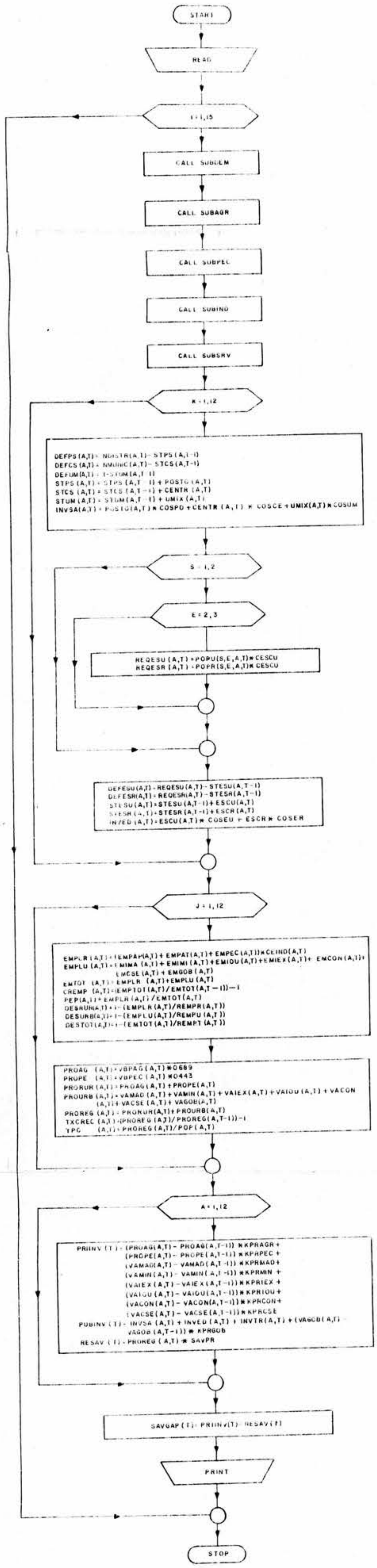
Thus, the economic feasibility of the strategy depends on the ability of regional authorities to obtain resources from the Central Government for financing public investment requirements and manipulating available policy instruments so as to attract private resources to match the savings gap determined in (GRL-19).

Finally, a graphic summary of the operations performed by the composite model is presented in the flow-chart of the computer programme shown in Fig. 7.2, which also includes the health and education sectors of the physical and environmental submodel.

7.3 OPERATION OF THE MODEL

The model thus presented is composed of 19 behavioural equations and 82 identities which comprise a large number of exogenous variables, endogenous variables, lagged endogenous variables, policy instruments and parameters. It was designed as an aggregate of partial submodels which were estimated separately and then assembled into an overall structure.
For a better understanding of the way the model operates, this section contains a review of some critical issues such as the treatment of the variables in each submodel, transfers of variables between submodels and between time periods and the relationships between policy inputs and the model's output.

Figure 7.2
FLOW CHART OF THE COMPOSITE MODEL



7.3.1 TREATMENT OF VARIABLES IN THE SUBMODELS

The structure of submodels and sectors was described in some detail in previous chapters together with information requirements and the type of results generated.

In order to provide a clear view of the incidence of submodels and sectors on aggregate forecasts and also of the way in which they interact it seems necessary to summarize the input - output relationships taking place in each submodel and to identify variables being transferred between submodels and sectors. A synoptic view of these input-output and interdependence relationships is presented in Fig. 7.3 .

The demographic and employment submodel requires the exogenous definition of the population of the base year per programme-area disaggregated by sex and age-strata, and also of some coefficients. These coefficients, that are assumed as constants for the whole simulation period, are: masculinity rate at birth, survival and fertility rates by sex and age - strata, and participation rates for urban and rural population also disaggregated by sex and age-strata.
Besides these exogenous elements, maximum acceptable unemployment rates are introduced as policy variables and rates of growth of total employment by programme-areas (including the proportion of total employment provided by primary activities) are also required. These employment growth rates are determined exogenously for the base year and generated by the composite model for subsequent years of the simulation.

The output of this model consists of estimates of the population per programme-area for each year of the simulation period disaggregated by sex and age cohort. It also generates for the urban and rural sectors of each programme-area estimates of total population, labour force and of the requirement for jobs derived from available human resources and the employment policy objectives defined.

LEGEND

SYMBOLS

(A) Programme-area
(T) Year
(AGR) Economic submodel, agricultural sector
(CAT) Economic submodel, cattle-raising sector
(CSG) Economic submodel, Tertiary sector
(DEM) Demographic and employment submodel
(GRL) Composite model
(IND) Economic submodel, industrial sector
(PHY) Physical submodel

LAGGED ENDOGENOUS VARIABLES

ANPP(A,T) = cattle/pastures ratio (CAT)
CREMP(A,T) = rate of growth of total employment (GRL)
GADO(E,S,A,T) = cattle, age strata E, sex S (CAT)
HA(1,A,T) = land devoted to rice and soya (AGR)
PEP(A,T) = proportion of primary employment (GRL)
PEXT(S,T) = rate of extraction , sex S (CAT)
POP(S,E,A,T) = population, sex S, age-strata E (DEM)
STCS(A,T) = number of existing health center (PHY)
STESR(A,T) = number of existing schools, rural zones (PHY)
STESU(A,T) = number of existing schools, urban zones (PHY)
STPS(A,T) = number of existing health posts (PHY)
STUM(A,T) = number of existing mixed health units (PHY)
VAIEX(A,T) = added value of export industries (IND)
VAMIN(A,T) = added value of mining industries (IND)

POLICY VARIABLES

CENTER(A,T)= number of health centres (PHY)
CRAG(T) = credits for agriculture (AGR)
CRAP(T) = credits for agriculture and cattle raising (AGR)
CRPC(T-1) = credits for cattle raising, normal expenses(CAT)
CRPE(T-1) = total credits for cattle raising (CAT)
ESCR(A,T) = number of schools, rural zones (PHY)
ESCU(A,T) = number of schools, urban zones (PHY)
GCEST(T) = current expenditure state government (CSG)
HA(2,A,T) = land devoted to coffee plantations (AGR)
HA(3,A,T) = land devoted to sugar-cane plantations (AGR)
IMARO(T) = credits for housing and public investment (CSG)
METIEX(A,T) = rate of growth of export industries (IND)
METMIN(A,T) = rate of growth of mining industries (IND)
POSTO(A,T) = number of health posts (PHY)
PREC(1,T-1) = price of rice (AGR)
PRECA(T-1) = price of beef to the farmer (CAT)
ROEMP(T) = rural open unemployment rate (DEM)
RUEMP(T) = rural underemployment rate (DEM)
TOPEN(T) = total open unemployment rate (DEM)
TUNDE(T) = total underemployment rate (DEM)
UMIX(A,T) = number of mixed health units (PHY)

ENDOGENOUS VARIABLES

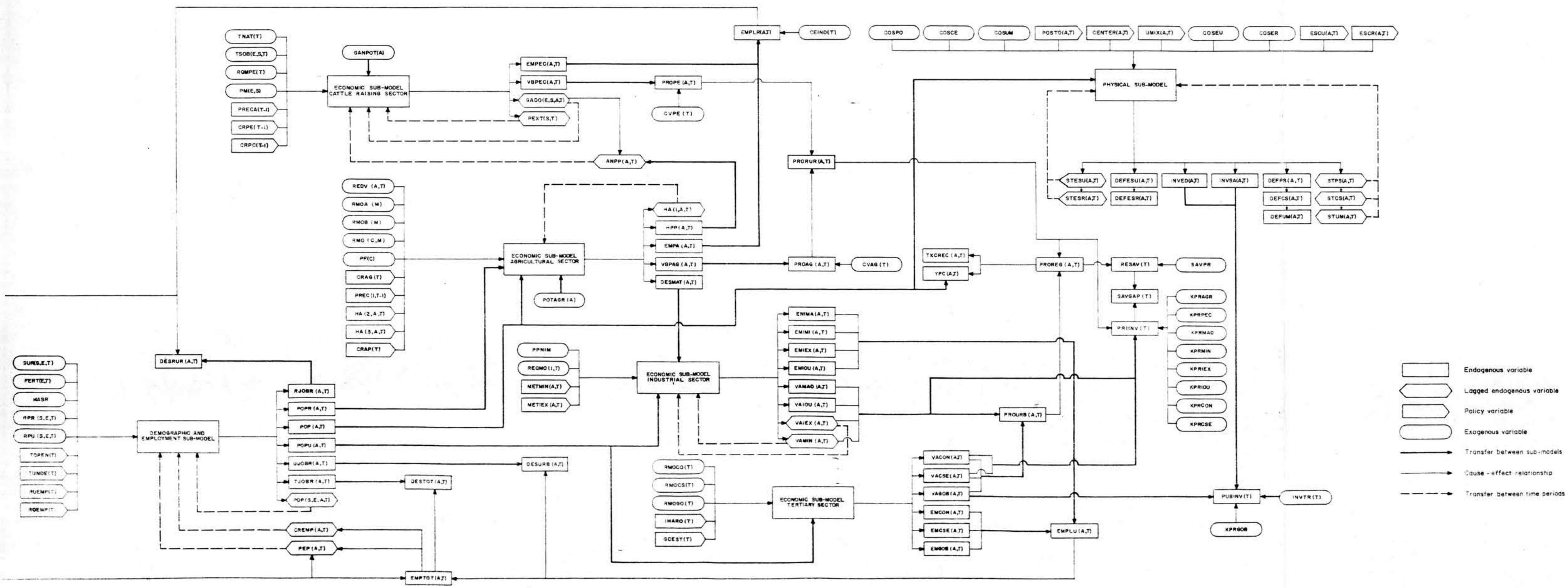
DEFCS(A,T) = shortage of health centres (PHY)
DEFESR(A,T) = shortage of schools rural zones (PHY)
DEFESU(A,T) = shortage of schools ,urban zones (PHY)
DEFPS(A,T) = shortage of health posts (PHY)
DEFUM(A,T) = shortage of mixed health units (PHY)
DESMAT(A,T) = deforested area (AGR)
DESRUR(A,T) = rural unemployment rate (GRL)
DESTOT(A,T) = total unemployment rate (GRL)
DESURB(A,T) = urban unemployment rate (GRL)
EMCON(A,T) = employment in civil construction (CSG)
EMCSE(A,T) = employment in commerce and services (CSG)
EMGOB(A,T) = employment in government (CSG)
EMIEX(A,T) = employment in export industries (IND)
EMIMI(A,T) = employment in mining industries (IND)
EMIOU(A,T) = employment in diverse industries (IND)
EMPA(A,T) = agricultural employment (AGR)
EMPEC(A,T) = cattle raising employment (CAT)
EMPLU(A,T) = total urban employment (GRL)
EMPLR(A,T) = total rural employment (GRL)
EMPTOT(A,T) = total employment (GRL)
EMIMA(A,T) = employment in timber industries (IND)
HPP(A,T) = land devoted to pastures (AGR)
INVED(A,T) = total investments, construction of shools(PHY)
INVSA(A,T) = total investments,construction of health units (PHY)
POP(A,T) = total population (DEM)
POPR(A,T) = rural population (DEM)
POPU(A,T) = urban population (DEM)
PRIINV(T) = required amount of private investment (GRL)
PROAG(A,T) = agricultural product (GRL)
PROPE(A,T) = cattle-raising product (GRL)
PROREG(A,T) = regional product (GRL)
PROURB(A,T) = urban product (GRL)
PRORUR(A,T) = rural product (GRL)
PUBINV(T) = required amount of public investment (GRL)
RESAV(T) = regional savings (GRL)
RJOBR(A,T) = rural job requirements (DEM)
SAVGAP(T) = private savings gap (GRL)
TJOBR(A,T) = total job requirements (DEM)
TXCREC(A,T) = annual growth rate of regional product (GRL)
UJOBR(A,T) = urban job requirements (DEM)
VAIOU(A,T) = added value of diverse industries (IND)
VAMAD(A,T) = added value of timber industries (IND)
VACON(A,T) = added value of civil construction (CSG)
VACSE(A,T) = added value of commerce and services (CSG)
VAGOB(A,T) = added value of government (CSG)
VBPAG(A,T) = value of agricultural production (AGR)
VBPEC(A,T) = gross product of cattle raising (CAT)
YPC(A,T) = product per capita (GRL)

EXOGENOUS VARIABLES

CEIND = total empl./ direct empl. ratio, rural sector (GRL)
COSCE = Unit cost,health centre (PHY)
COSER = Unit cost, rural school (PHY)
COSEU = Unit cost, urban school (PHY)
COSPO = Unit cost, health post (PHY)
COSUM = Unit cost, mixed unit (PHY)
CVAG(T) = added value/gross value of production ratio,agriculture (GRL)
CVPE(T) = added value/gross value of production ratio, cattle raising (GRL)
FERT(E,T) = rate of fertility, age strata E (DEM)
GANPOT(A) = maximum supportable cattle stock (CAT)
INVTR(T) = required amount of investment in transport (GRL)
KPRAGR = capital-product ratio, agriculture (GRL)
KPRCON = capital-product ratio, civil construction (GRL)
KPRCSE = capital-product ratio, commerce and services (GRL)
KPRGOB = capital-product ratio, government (GRL)
KPRIEX = capital-product ratio, export industries (GRL)
KPRIOU = capital-product ratio, diverse industries (GRL)
KPRMAD = capital-product ratio, timber industries (GRL)
KPRMIN = capital-product ratio, mining industries (GRL)
KPRPEC = capital-product ratio, cattle-raising (GRL)
MASR = rate of masculinity at birth (DEM)
PF(C) = physi l productivity, crop C (AGR)
PM(E,S) = average weight, cattle age strata E,sex S (CAT)
POTAGR(A) = potential land for agriculture (AGR)
PPNIM = national product, per capita, timber industry (IND)
REDV(A,T) = road network (AGR)
REQMO(I,T) = labour req. per unity of prod., industry I(IND)
RMO(C,M) = labour req. per hectar, crop C, month M (AGR)
RMOA(M) = labour req. per hectar of rice, manual crop, month M (AGR)
RMOB(M) = labour req. per hectar of rice, mechanized crop month M (AGR)
RMOCO(T) = labour req. per unity of prod.,civil construction (CSG)
RMOCS(T) = labour req. per unity of prod.,commerce and services (CSG)
RMOGO(T) = labour req. per unity of prod., government (CSG)
RPR(S,E,T) = rural part. rate, sex S, age strata E (DEM)
RPU(S,E,T) = urban part. rate, sex S , age strata E (DEM)
RQMPE(T) = labour req. per unity of cattle (CAT)
SAVPR = average propensity to save (GRL)
SUR(S,E,T) = rate of survival ,Sex S,age strata E (DEM)
TNAT(T) = cattle birth rate (CAT)
TSOB(E,S,T) = cattle survival rate, age strata E,sex S(CAT)

FIGURE 7.3

FLOWCHART OF THE STRUCTURE OF THE SIMULATION MODEL



The economic submodel , for its part, is composed of four sectors (agriculture, cattle raising, industry and tertiary activities) which are run independently. Aggregation of their output takes place in the so called "composite model".

The inputs of the agricultural sector comprise the extension of the road network of each programme-area and its expected variations during the simulation period, monthly requirements of labour for each crop and the potential area for agriculture of each programme-area as exogenous variables. Total and rural population for each programme-area are transferred from the demographic and employment submodel. On top of these variables the model requires precise values for the following policy instruments: the amount of credit for agriculture and cattle raising, the price of rice, and the amount of land devoted to sugar cane and coffee plantations. With these elements the agricultural sector of the economic submodel generates estimates of sectorial employment and the gross value of production for each year of the simulation period. It also quantifies other variables that are used in other sectors of the economic submodel such as the amount of land devoted to planted pastures (for the cattle raising sector) and the amount of land deforested each year (for the industrial sector) together with the amount of land allocated to rice and soyabeans which is used as a lagged endogenous variable in the proper agricultural sector.

The cattle raising sector , requires cattle birth and survival rates, labour requirements and the average weight of cattle as exogenous variables. The amount of land devoted to pastures is transferred from the agricultural sector and potential cattle stock per programme-area is introduced as an ecological constraint. Policy inputs of this sector of the model are the price of meat and the amount of credit granted to this activitiy both for capital and cur rent expenses. The output of this cattle raising submodel comprises annual estimates of total employment, gross value of production, cattle stock and extraction rates. The two latter variables are used as lagged endogenous variables in the same submodel.

The industrial sector distinguishes four branches of regional industry (timber industry, mining, export industry and diverse industries). Any simulation needs sectorial requirements of labour per unit of product and added value per capita of the timber industry at the national level as exogenous variables. It also requires the transfer of urban population (from the demographic and employment submodel) and the amount of deforested land (from the agricultural sector), while the rates of growth of the mining and export industries constitute its policy inputs. The output of this sector of the model comprises estimates of employment and the added value of each branch of regional industry. The added value of the mining and export industries is also used as a lagged endogenous variable for simulating subsequent years.

The fourth sector of the economic submodel comprises civil construction, commerce and services and government. Its inputs include the sectorial requirements of labour per unit of production as exogenous variables, urban population as a transfer from the demographic submodel, and the loans granted by the National Housing Bank (BNH), public investments in roads and the current expenditure of State Governments as policy instruments. With these elements this submodel generates estimates of added value and employment for each of these sectors of economic activity.

As mentioned above, education and health are the only sectors of the physical and environmental submodel included in the simulations. The transport and environmental sectors were processed independently and their outputs were fed into the model as exogenous variables.

The education and health sectors utilize the cost of schools and health facilities as exogenous variables, urban and rural population as a transfer from the demographic submodel, and the number of physical units to be built each year as a policy input. Their results are composed of the stock and deficit of education and health facilities per programme-area and the volume of investment required each year for meeting sectorial objectives.

The outputs of these partial submodels are integrated by the composite model through the operations described in sections 7.1 and 7.2 above and represented in Fig. 7.3 by thick and dashed arrows. Such operations lead to the quantification of aggregate production and employment per programme-area and also to the deduction of some indices of economic performance of the simulated policies such as income per capita, rate of growth of total production, unemployment rates, investment requirements, savings gap, etc.

7.3.2 TRANSFERS OF VARIABLES BETWEEN SUBMODELS AND FEEDBACK RELATIONSHIPS.

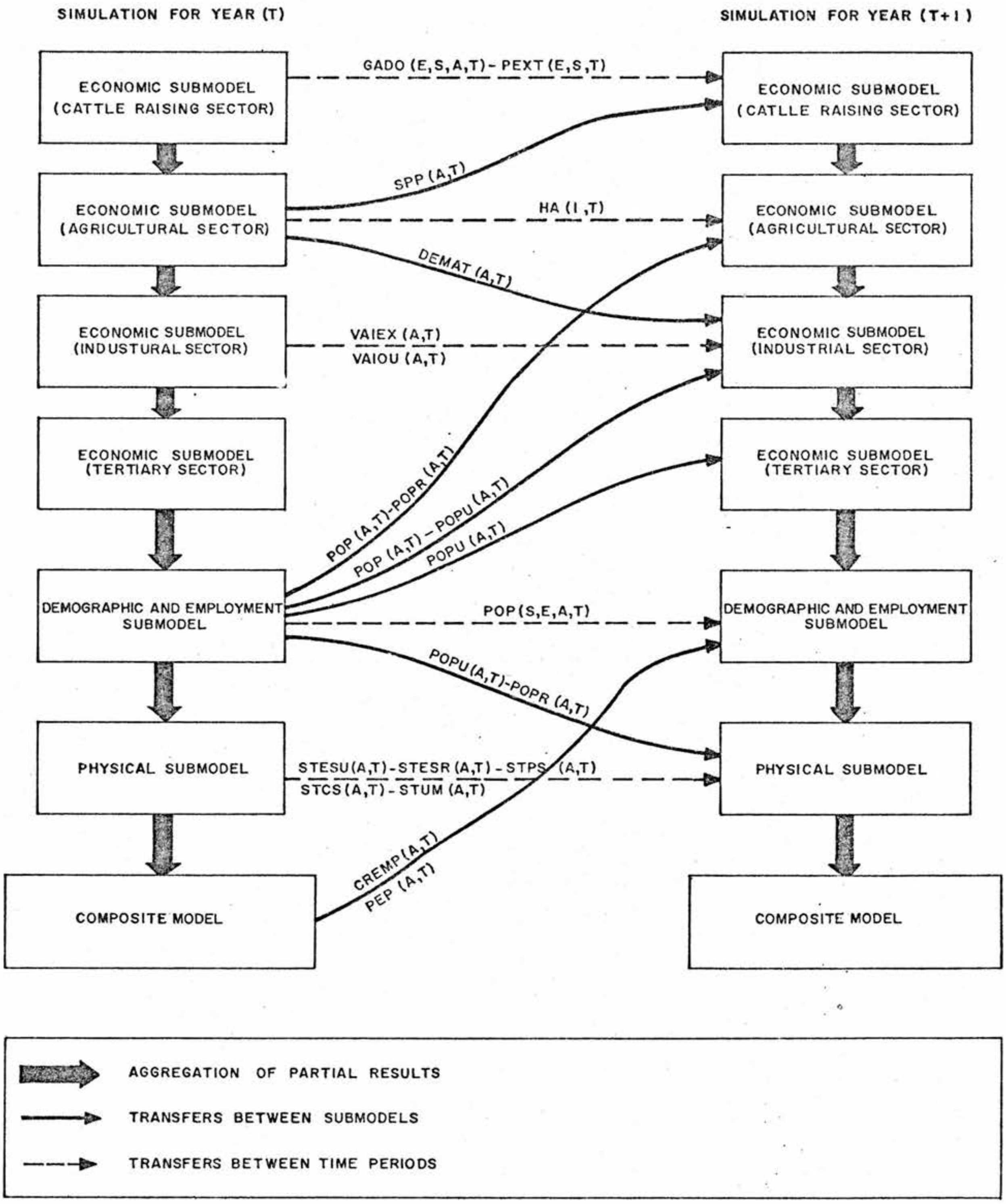
The integration of partial submodels and the simulation of the overall model for several years involve a few practical problems, transfers of variables between submodels and between time periods being the most relevant ones. In fact, each simulation implies running the model for twelve programme-areas and also for a period of ten or fifteen years. Thus the amount of information to be stored and transferred between submodels, aggregated for generating regional estimates or used as lagged endogenous variables for subsequent years of the simulation becomes extremely great.

Fig. 7.4 presents a synoptic view of the operations performed with endogenous variables (aggregation, transfers between time-periods and transfers between submodels).

The aggregation of partial results for generating global estimates at the programme-area level or for the whole region requires a careful consideration of the conceptual differences between

FIGURE 7.4

RELATIONSHIPS IMPLIED BY THE INTEGRATION OF PARTIAL SUBMODELS



the variables quantified in each submodel and sector. For example, the agricultural and cattle raising sectors of the economic submodel product estimates of direct employment and of gross value of production generated by such activities, while the industrial and tertiary sectors forecast total employment and added value. Thus to obtain total employment and production per programme-area (or at the regional level) such variables cannot be added mechanically. In these cases special coefficients for transforming direct employment and gross value of production into estimates of total employment and added value respectively should be utilized in order to make aggregation possible.

Transfers of variables between time periods, for their part, consist of the use of endogenous variables generated by any submodel in year T for predictive purposes in the same submodel in year T+1. These feedback relationships are represented in Fig. 7.4 by dashed arrows and also described in Table 7.1.

The use of lagged endogenous variables makes the model iterative. This is to say results of simulations for a given year depend on the results obtained for the previous year plus other exogenous and policy variables. In this way any deviation derived from errors in the estimation of parameters or from changes of exogenous variables is repeated during the whole forecasting period leading to a progressive amplification of the initial deviation.

The third type of relationship entailed by the integration of submodels, refers to transfers of variables between submodels. Initially, some of these transfers were designed to take place in the same year of the simulation period. However, theoretical considerations led to the definition of such transfers as the use of endogenous variables generated by a submodel (or sector) in year T, as explanatory variables in other submodel (or sector) in year T+1.

TABLE 7.1

VARIABLES TRANSFERRED BETWEEN TIME PERIODS

VARIABLE	GENERATED		UTILIZED IN T+1 FOR DETERMINING
	SUBMODEL (Sector)	YEAR	
Population by sex and age cohort per Programme-area - POP(S,E,A,T)	Demographic Submodel	T	POP(S,E,A,T+1)
Cattle by sex and age cohort per programme-area - GADO(E,S,A,T)	Economic Submodel (cattle raising sector)	T	GADO(E,S,A,T+1)
Extraction rate of cattle by sex - PEXT(E,S,T)	Economic Submodel (cattle raising sector)	T T-1 T-2	PEXT(E,S,A)
Land devoted to rice and soya - HA(1,T)	Economic Submodel (agricultural sector)	T T-1	HA(1,T+1)
Added value of export industries and diverse industries per progr. area-VAIEX(A,T) - VAIOU(A,T)	Economic Submodel (industrial sector)	T	VAIEX(A,T+1) VAIOU(A,T+1)
Stock of schools and health units per Programme - area - STESU(A,T) STESR(A,T) - STPS (A,T) - STCS(A,T) STUM(A,T)	Physical Submodel	T	STESU(A,T+1) STESR(A,T+1) STPS(A,T+1) STCS(A,T+1) STUM(A,T+1)

Although these transfers involve few variables they are very important for the stability of the whole model because aggregate results are relatively sensitive to changes in some of them. The variables transferred between submodels are demographic forecasts (total, urban and rural population), area deforested each year, land devoted to pastures, rates of growth of total employment and primary employment/total employment ratios (see Table 7.2).

Demographic forecasts do not generate major problems because they are relatively stable and also because sectorial results are not very sensitive to changes of these variables. (See section on sensitivity analysis in Appendix III).

However, the other variables transferred between submodels generate significant impacts on sectorial and aggregate projections. As mentioned earlier, behavioural equations of the model were calibrated either on a sample of cross-section data (each observation corresponding to a programme-area) or on time series data representing the regional situation and then disaggregated at the programme-area level. Since regional averages tend to be more stable than observations for individual programme-areas the model simulated at such levels of spatial disaggregation will tend to be more stable than if run for regional variables. Instability derives from the fact that the distortions that may arise in any submodel for a particular programme-area (due to critical values of policy instruments or exogenous variables) will be transferred to other submodels and to subsequent years of the simulation. In this way, feedback loops, represented by transfers of variables between submodels and time periods, are likely to lead to an imbalance in the model's overall structure.

Thus, in order to prevent nonsensical results, it was necessary to calibrate the composite model. Such calibration was carried out introducing special balancing mechanisms both into the structure of the model and into the computer programme. Details of these adjustments are discussed in Appendix III.

TABLE 7.2

VARIABLES TRANSFERRED BETWEEN SUBMODELS

	GENERATED		UTILIZED		
	SUBMODEL (SECTOR)	YEAR OF SIMULATION	SUBMODEL (SECTOR)	YEAR OF SIMULATION	FOR ESTIMATING
Total population per Programme-area - POP(A,T)	Demographic Submodel	T	Economic Submodel (Agricultural sector)	T+1	CDIST(A,T+1)
			Economic Submodel (Industrial sector)	T+1	Lower limit of activity of timber industries
Rural population per Programme-area - POPR(A,T)	Demographic Submodel	T	Economic Submodel (Agricultural sector)	T+1	HA(4,A,T+1)
			Physical submodel	T+1	REQESR(A,T+1)
Urban population per Programme-area - POPU(A,T)	Demographic Submodel	T	Economic Submodel (Industrial submodel)	T+1	EMIOU(A,T+1)
			Economic Submodel (Tertiary sector)	T+1	EMCSE(A,T+1)
			Physical Submodel	T+1	REQESU(A,T+1)
Land devoted to pastures per Progr- Area - SPP(A,T)	Economic Submodel (Agricultural sector)	T	Economic Submodel (cattle raising sector)	T+1	ANPP(A,T+1)
Deforested area per Programme-area - DESMAT(A,T)	Economic Submodel (Agricultural sector)	T	Economic Submodel (Industrial sector)	T+1	VAMAD(A,T+1)
Rate of growth of total employment per Programme-area - CREMP(A,T)	Composite model	T	Demographic Submodel	T+1	NMR(S,E,A,T+1)
Primary employment/total employment ratio- PEP(A,T)	Composite model	T	Demographic Submodel	T+1	CPR(A,T+1)

7.3.3 POLICY INPUTS AND RESULTS OF THE MODEL

Once calibrated, (i.e. behavioural equations are fitted on empirical data and exogenous variables are given precise values) and when all adjustments to the computer programme are finished, the model is ready to simulate the behaviour of the regional system under the conditions determined by the set of policy variables fed as inputs. Each simulation of the model generates a time series of values for each endogenous variable. This makes it possible to establish a cause-effect relationship between policy variables and the model's output.

The field of "experimental design" provides a very useful methodological framework for systematizing the type of experiments that it is possible to carry out with a simulation model. In the normal terminology of experimental design, policy variables are denominated "factors" and the model's output "response".

As Naylor points out, in a situation like ours, two different types of experimental objectives can be defined: "a) to find the combination of factor levels at which the response variable is optimized and b) to explain the relationship between the response variable and the controllable factors in the experiments" (NAYLOR, 1969; p.5).

Since the model was built mainly for estimating the possible impact on the regional system that would derive from the implementation of different development strategies and partial policies, it was used to carry out experiments of the second type. The model can also be used for selecting an optimum strategy or policy but in this case a special optimisation function would be required.

Whatever the type of experiments to be carried out using the model two basic problems must be solved. They are known as the "problem of size" and the "multiple response problem".

The problem of size refers to the fact that the number of experiments (simulations) required to study the effects of all combinations of factors is the product of the number of levels for each of the factors in the experiment. Assuming that each policy variable of our model can only adopt three values or levels (high, medium and low), a full factorial design (i.e. an experiment involving all possible combinations of factors) for our twelve basic policy variables would require 3^{12} simulations (531,441 model runs). Obviously it is not possible nor desirable to carry out such a job. For overcoming this difficulty special experimental designs (fractional factorial designs) are used which make possible the study of the main effects and also two-factor interactions.

In our case, the problem of size was solved by reducing the number of factors to those policy variables that could be controlled by regional authorities, and the number of levels of such policy instruments was reduced to a few options studied by EDIBAP. In fact, the factors utilized in simulations were public expenditure, credit for agriculture and cattle raising, investment projects for export industries, public investment in roads and social sectors (education and health). For each factor two levels were established except for public investment which comprised three levels. Additionally two hypotheses about land productivity were tested. For the other policy instruments a single pattern of behaviour was assumed. In this way 48 different combinations of factors (each of which represented a particular development strategy) were explored plus one representing an extrapolation of current trends. Chapter 8 analyses the expected impact of the selected strategy as compared with the extrapolation of historic trends.

The multiple response problem refers to the difficulty of evaluating the effect of a factor when the model generates many different response variables. For solving this problem only three response variables were established as relevant and each simulation was treated as three different experiments. Thus the impact of each strategy was assessed in terms of income per capita, unemployment rates and the savings gap . All these indeces were calculated at the regional level. Final selection was performed on the basis of income per capita among a few strategies that presented acceptable values for the other response variables.

CHAPTER EIGHT

SIMULATION OF THE MODEL

8. SIMULATION OF THE MODEL

Having, in previous chapters, briefly characterized the socio economic and physical situation of the study area and described the main features of the model built for estimating the possible impact of different development policies, we proceed in this chapter with the quantification of the effects to be expected from the implementation of a specific development strategy in the Upper Paraguay River Basin.

The analysis concentrates exclusively on the programme areas included in the basin (*) and is based on the results of the simulations performed on the model.

The formulation of the proposed strategy for regional development was a complex and highly iterative process which involved a large number of simulations and led to significant modifications to the model. An explanation of this process and a detailed discussion of its problems is presented in Chapter 9.

The assessment of any development strategy entails the evaluation of its expected effects against the forecast regional situation if no special measures are undertaken. Thus, in the interests of achieving a systematic presentation of the model's results, this chapter is divided into three sections.

(*) The model was calibrated for the whole area of the States of Mato Grosso and Mato Grosso do Sul; thus independent variables utilized in the simulations refer to that area. The results of the simulations are composed of information related to each programme area, some of which were later aggregated at the State and Basin levels.
Since EDIBAP is concerned exclusively with the area of the Upper Paraguay River Basin a great part of the analysis carried out omitted any consideration of the programme areas located outside the Basin. Thus, the programme areas of Diamantino, Barra do Garças, Tres Lagoas and Dourados have been omitted from this chapter.
For easy of exposition some references are made to the northern and southern subregions. They correspond to the part of the river basin belonging to the States of Mato Grosso and Mato Grosso do Sul respectively.

Section 8.1 deals with the expected regional situation and contains a synthesis of the results of the simulations carried out on the assumption that no special treatment is given (by the central Government) to the Upper Paraguay River Basin.

The following section is devoted to an explanation of the main features of the proposed development strategy. It is complemented by Appendix II, which presents a synthesis of the investment projects and programmes of public action that make the strategy operative. Finally, section 8.3 studies the probable impact of the proposed strategy as compared with the forecasts presented in Section 8.1. It is complemented by Appendix III which contains a detailed discussion of the model's results.

8.1 THE EXPECTED REGIONAL SITUATION

It can be concluded from the previous chapters that the recent development of the region shows a high degree of dependence, both as regards extra-regional factors and as far as the limits to the use of its natural resources are concerned. For this reason, before characterizing the regional situation forecast for the period 1985-1990 it is necessary to define the expected behaviour of the variables that condition its development.

8.1.1 Hypothesis concerning the future behaviour of the variables that explain regional development

The recent economic and demographic growth of the region, like the development of any peripheral region, derives from a substantial flow of human and financial resources designed to consolidate the region's integration into the national economic system. In the case of the Upper Paraguay River Basin these interregional transfers are the product both of official policies intended to discipline the utilization of the national land area and of the expectations generated in the private sector by the process of expansion of the agricultural frontier.

At this stage of development of the Upper Paraguay River Basin the determinants of growth are exogenous, with the region playing the role of a mere receiver of investment and contingents of population. This situation should be reversed in the near future with the region proceeding to direct (particularly through the State Governments) both the process of utilization of its internal space and the action of the private sector, through the identification of projects in the secondary and tertiary sectors.

At the present time, the level and composition of public expenditure and the transfers of capital, together with the possibilities of expanding the agricultural frontier and increasing the productivity of the natural resources, are undoubtedly the most important determinants of regional development in the short term.

In order to explicate the suppositions underlying the perspective analysis, the recent evolution and expected trends of the above-mentioned determinants of regional growth are presented below.

a) The action of the public sector

The action of the public sector showed an extraordinary dynamism during the previous decade. It is reasonable to assume that this trend will change in the near future owing to the limits on public expenditure resulting from the economic policy measures adopted by the Federal Government in 1980.

Quantifying the volume of activities and investments of the public sector in the region is relatively complex, since they operate at three different levels (federal, state and local government agencies), and there are sizable transfers of resources among agencies of all three levels. This,added to the fact that the information concerning level of activity, current expenditure, capital expenditure, etc. is not homogeneous as regards territorial scope of reference, has made it necessary to adopt the state government as the representative element of the entire public sector.

The historical trend of the government expenditure of the former State of Mato Grosso shows high and sustained growth rates of current expenditure, with an average rate of 21% per annum, between 1968 and 1978 and a rather more dynamic trend, albeit with significant oscillations, in the case of capital expenditure.

Current expenditure accelerated between 1968 and 1975 from a rate of 5.8% at the start of this period to 36.6% p.a. at the end. From 1976 this rates began to decline, falling to 16.4% in 1978.

Capital expenditure for its part registered a fall in absolute values in the years 1970-71 and in 1977. This difference in behaviour between current and capital expenditure is due to the fact that the former is difficult to squeeze since it consists, in large part, of salaries and unavoidable operational expenditure. Capital expenditure is usually associated to specific works that can, in times of financial difficulties, be postponed.

With these considerations as a starting point it is possible to postulate that current expenditure will, in the period 1981-85, register growth rates markedly lower than the historical ones and somewhat lower than the estimated rates of population growth. It is assumed that from 1985 the increase in current expenditure will be approximately 5% per annum.

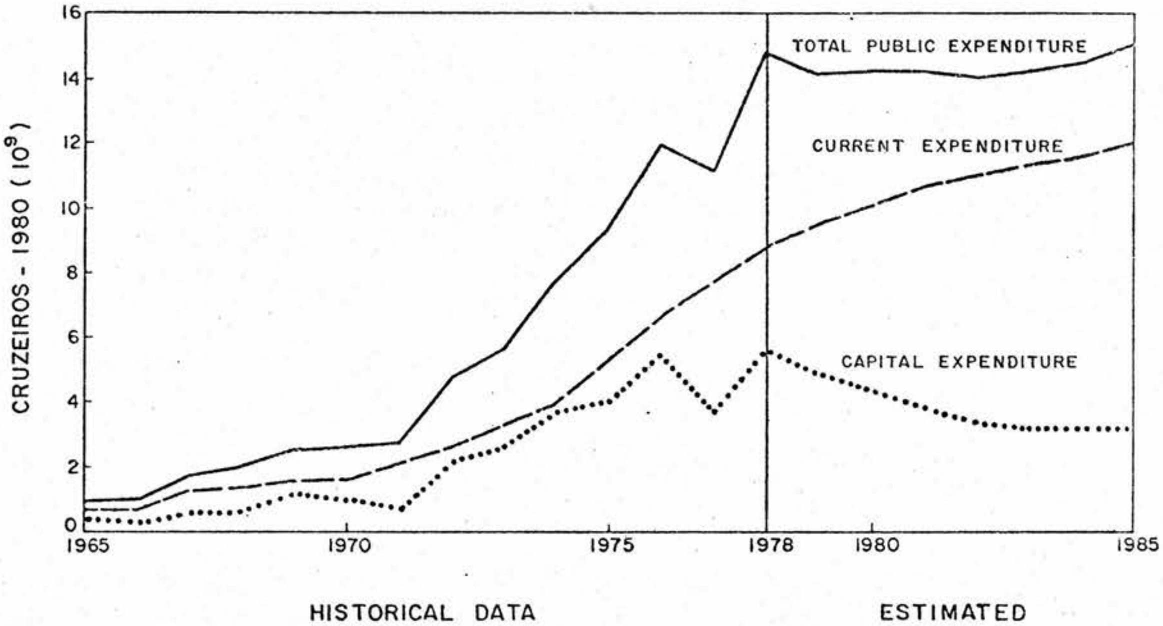
In the case of capital expenditure it is postulated that no major public works will be started in the next five years and that the level of investment will be sufficient for the termination of the projects already begun(see Fig. 8.1).

b) Credit and capital transfers

The flow of resources to finance investments in the region is channelled fundamentally through the banking system,which even passes on the resources destined for special government programmes. Despite the lack of conclusive antecedents, a number of partial elements allow one to assert that the region has registered no significant contributions of private net capital. Private investment has basically taken the form of indebtedness to the regional banking system on the part of agents resident in other states. For this reason it is estimated that the behaviour of the interregional flows

Figure 8.1

STATES MATO GROSSO AND MATO GROSSO DO SUL
PUBLIC EXPENDITURE



of capital will be closely correlated with the evolution of credit, especially that destined for the agriculture and cattle-raising sectors.

Between 1969 and 1978 credit granted in the region for these sectors grew at a cumulative annual rate of 41.5%, which means that at the end of this period the sum of the loans granted was 22 times the initial amount, at constant prices.

This growth rate of credit bore no relation either to the expansion of the land area under cultivation or to the growth in stockbreeding, as there was a substantial increase both in the credit granted per hectare under cultivation and in the credit/added value relation.

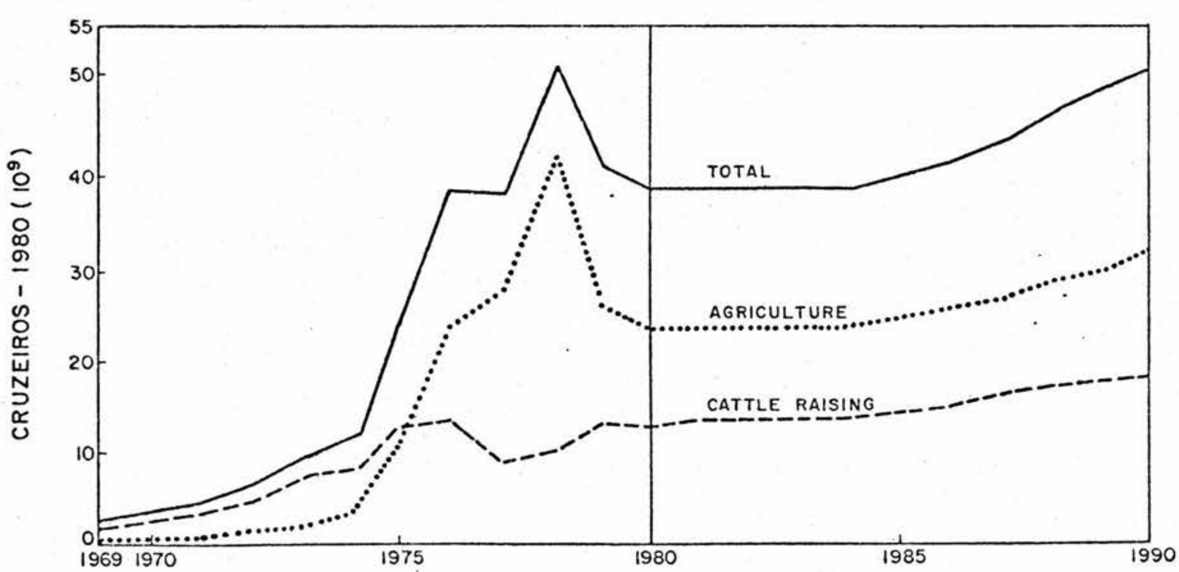
This situation is basically due to the relative abundance of credit , interest rates that are actually negative, and the lack of an efficient mechanism for supervising its application.

In 1979 a change in the trend was registered with a significant fall in the quantity of loans granted, a fall that continued in 1980, but to a lesser extent. Bearing in mind the measures taken by the Government in the last year to combat inflation it is possible to predict that the downward trend, albeit less marked, is likely to be maintained in the near future, until it stabilizes at a level more in accordance with the real needs of the agricultural sector.

In view of the fact that interest rates have risen simultaneously with the fall in loans it is reasonable to assume that both these factors will lead to a normalization of the credit/added value relation. (See Fig. 8.2)

Figure 8.2

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
CREDITS FOR AGRICULTURE AND CATTLE-RAISING



HISTORICAL DATA ESTIMATED

c) Land productivity

In order to assess the performance of agricultural productivity, rice was chosen on account of it being the most representative crop (accounting in 1978 for almost 65% of the land under cultivation in the States of Mato Grosso and Mato Grosso do Sul).

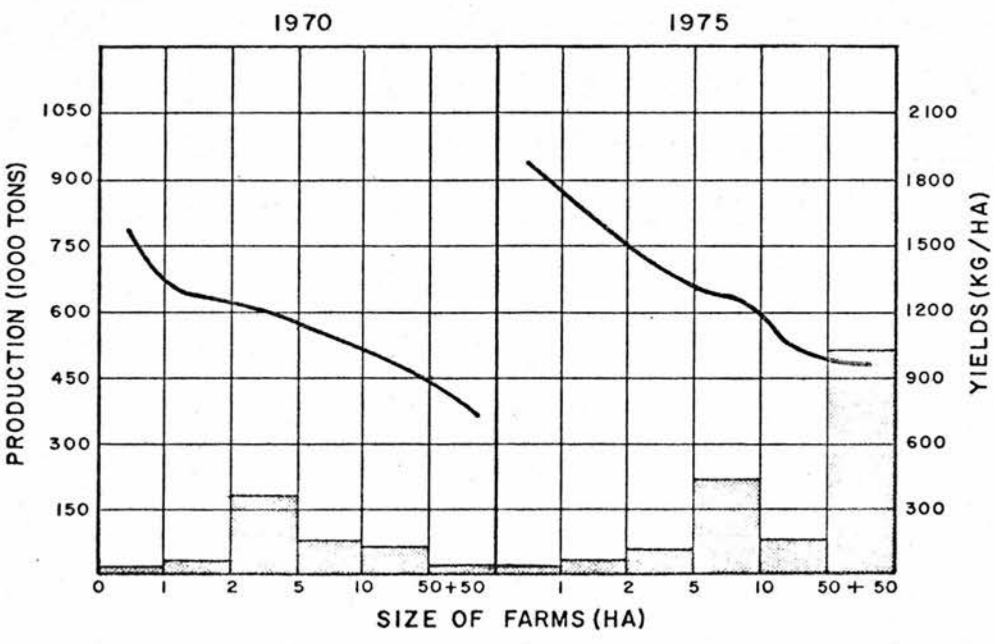
An examination of the historical behaviour of the yields of the rice crop reveals a downward trend, for both the northern and southern subregions. Both subregions show differences from the start of the series (1968), the fluctuations in annual yields being greater in the south than in the north which is explained by the southern area's greater exposure to climatic fluctuations.

Two clearly visible phenomena make it possible to estimate the future behaviour of agricultural yields.

In the first place, an analysis of the yields registered in the years of the agricultural censuses of 1970 and 1975 indicates that the planted areas tend to be concentrated in the strata of larger farms. Since production presents a lower degree of concentration than cultivated area, this means that average yields decline as the size of farms increases (See Fig. 8.3).

Figure 8.3

STATES OF MATO GROSSO AND MATO GROSSO DO SUL
PRODUCTION AND YIELDS OF RICE



On the other hand, a comparison between the series of annual yields and the year-to-year variation in the area under cultivation makes it possible to detect a marked fall in yields whenever there is a sizeable increase in the area under cultivation from one year to the next, such as that which occurred between 1974 and 1976. Productivity levels tend to stabilize again when the area under cultivation becomes stabilized. This fact is explained by two probable causes:

i) Credit and price incentives tend to expand the area devoted to rice, even on land not suitable for this crop, with a view to the subsequent implantation of artificial pasture. The low yields achieved lead to negative economic (and probably financial) margins, with a resulting disincentive to the indiscriminate expansion of the areas under rice growing. A process of land selection, usually of new and more fertile lands, is thus set in train, stabilizing the whole area and bringing about a slight recovery in average productivity.

ii) The growing of soybeans has been started in recent years (from 1977) and with it the rotation of rice and soy, mainly in the southern area. A temporary recovery in average yields has been seen to result from this.

Future prospects concerning the behaviour of the productivity of rice are connected with its tendency to expand. It can be stated that the average yields from rice growing will fall in the medium term, especially in the north.

The figures for the minimum economic threshold are estimated to be as follows: an average of 1.000 - 1.200 kg/ha in the southern area and 1.200 - 1.300 kg/ha in the northern area, given the difference in costs of the transport of inputs and of the product itself.

In order to quantify future trends a historical series from 1968 to 1978 was prepared for the northern and southern subregions and for the region as a whole (See Table 8.1 and Fig. 8.4). A triennial average was calculated for consecutive years in order to compensate for the probable climatic influences. In this way a series of five three-year averages for the period 1968-1978 was obtained for the northern and southern sub-regions and for the region as a whole.

TABLE 8.1

TRENDS IN RICE YIELDS (KG/HA)

TRIENNIAL AVERAGES

YEARS	NORTHERN SUB-REGION	SOUTHERN SUB-REGION	TOTAL
1968-1970	1,940	1,593	1,883
1970-1972	1,857	1,867	1,860
1972-1974	1,777	1,743	1,760
1974-1976	1,587	1,287	1,423
1976-1978	1,567	1,327	1,447
1978-1980	1,547	1,307	1,393
1980-1982	1,526	1,307	1,385
1982-1984	1,447	1,266	1,329
1984-1986	1,373	1,225	1,277

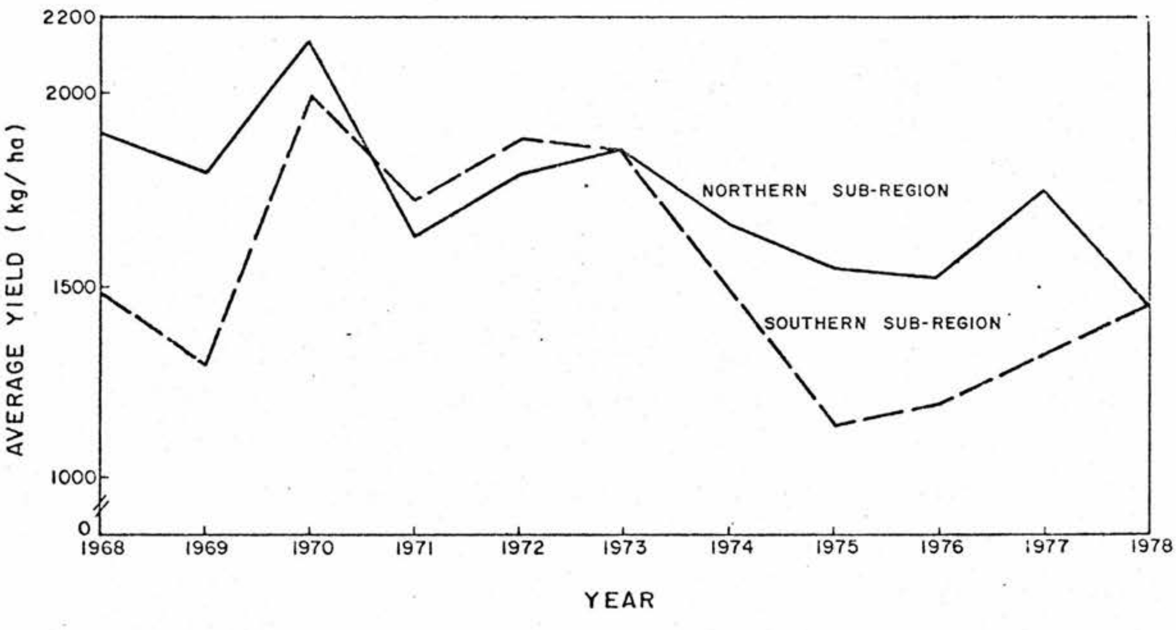
SOURCES: EMATER, CEPA, IBGE.

It should be noted that average yields declined by 4.3% in the northern sub-region every two years until 1974, that is a total of 163 kg/ha in the first six years and 2.58% on the annual average for the whole period. In the southern sub-region, for its part, the average dropped at a rate of 1.55% every two years, with yields that were extremely unstable and fluctuating.

The projection of the cultivated area up to 1985 foresees a moderate increase in rice growing until the two-year period 1981-82 (1.26% per annum in the north and 3.1% in the south). It is expected that the corresponding yields will tend to remain at their present levels in the south and show a slight downward trend in the north in accordance with their behaviour between 1976 and 1978. A sizable increase in the rice-growing area is forecast between 1983 and 1985/6, with yields tending to fall again at the average rate of the period 1968-78 in both sub-regions. For the subsequent years, yields are expected to stabilize at the levels reached in 1985-86.

Figure 8.4

AVERAGE YIELDS OF THE RICE CROP



d) The possibility of expansion of the agricultural frontier

Since 1970 the region has experienced a rapid growth in the surface area under cultivation, in planted pasture ,and in the stocks of cattle.

Between 1970 and 1975 the surface area under cultivation practically doubled and has, since 1975, registered cumulative annual growth rates of around 10%.

These figures reflect the great expansion of agriculture in the southern sub-region (15% annual growth during the last decade) and a more moderate growth (9.6% per annum) in the northern sub-region.

The chances of expanding the agricultural frontier over the next ten years are different in the north from those in the south. In fact, in 1980, 43% of the land with agricultural potential was under cultivation in the southern sub-region, whilst the corresponding figure for the northern sub-region was only 30%. If the rates of expansion of the surface area under cultivation noted in the period 1970-80 in the state of Mato Grosso do Sul were maintained in the south, the class 1 and 2 soils suitable for cultivation (with the exception of the legal forest reserve) would become exhausted in 1983 and the surface area under cultivation would in 1985 exceed the surface area ecologically recommended for agriculture. On account both of the exhaustion of the agricultural frontier and of the difficulties implied by the incorporation of increasingly narrow margins it is possible to expect that the growth rate of the area under cultivation in the southern sub-region will progressively decline until it reaches 75% of the ecological limit in 1990.

In the northern sub-region, since the historical trend is less marked, no difficulties are foreseen in maintaining for the next ten years the same rate of incorporation of lands as that of the recent past.

8.1.2 Results of the simulation (Perspective Analysis)

In accordance with the hypotheses presented in the previous section,a marked fall in the growth rate of the regional economy is expected. In fact, it is estimated that during the present decade the annual growth rate will be of the order of 5.1% as compared with the 11% registered in the previous decade. This slowing down of the economic growth rate is likely to affect also the demographic behaviour and the rate of incorporation of new lands into agriculture and cattle-raising activities. This is due, on the one hand, to the fact that the migratory process (an element of high incidence in the demographic growth of the region) bears a close relationship to the increase in job opportunities and, on the other, to the fact that the opening up of the agricultural frontier has proceeded in a northwesterly direction, advancing beyond the boundaries of the region. This means that a sizable proportion of the areas to be incorporated are not situated within the region. The most relevant features of the perspective analysis are presented separately,in greater detail, below.

a) Population

During the 1970's the population of the study area grew at the rate of 4.84% per annum, reaching 1,589,135 inhabitants in 1980. This rate of growth is expected to fall in the next ten years, which will mean an absolute increase of about 650,000 persons in the period. (See Table 8.2)

TABLE 8.2

EXPECTED GROWTH OF THE REGION'S POPULATION

	1980	1985	1990
RURAL POPULATION	564,935	568,011	573,464
URBAN POPULATION	1,024,200	1,320,685	1,671,600
TOTAL POPULATION	1,589,135	1,888,696	2,245,064
% OF URBAN POPULAT.	64.5	69.9	74.5
RURAL WORK FORCE	190,739	193,631	196,548
URBAN WORK FORCE	330,036	430,838	550,583
TOTAL WORK FORCE	520,775	624,469	747,131

The fall in the rate of demographic growth should be greater in the northern sub-region. In fact, during the seventies the north grew at an annual rate of 5.8% and the south at 3.6% per annum. For the period 1980-90 these growth rates are expected to reach 3.9% and 3.0% respectively.

Supporting evidence for these expected falls lies in the fact that the historical growth rates registered by the north remained high as a result of a strong migratory process. With the disappearance of the exceptional factors that gave rise to this flow of people it is only natural that the rate of growth should progressively approach those of vegetative growth. The diminution in the dynamic area of population growth expected in the southern sub-region is due to the decrease in fertility rates throughout the country and also to the expected fall-off in migration to the area.

In accordance with the trends observed during the seventies, the process of urbanization is expected to intensify over the next few years, but at a declining rate. The percentage of urban (*) population rose from 49.1% in 1970 to 64.5% in 1980 and it is estimated that by the end of the present decade this figure will have reached about 75%. The causes of this slackening off in the process of urbanization are to be attributed chiefly to the fact that population densities in the region's rural zones are already relatively low and to the fact that, despite the existence of a significant process of mechanization of agriculture, the labour requirements in this sector are increasing.

From a spatial viewpoint significant variations in the demographic composition of the programme areas are expected. Cuiabá is likely to be the programme area showing the highest population growth, with an annual rate of 4.8%, followed by Cáceres (3.7%) and Campo Grande (3.5%). The programme area with the lowest population growth is likely to be Rondonópolis with only 2% per annum (See Table 8.3).

The forecast growth of the region's work force is closely related to the trend in population, although the figures are slightly higher. This greater increase in the work force as compared with the population (3.7% and 3.5% respectively) is due to the fact that migration entails a proportionally greater addition of working-age persons to the population than of the non-active strata. From the urban-rural composition viewpoint, a sizable increase in the urban work force (5.3% per annum) and a relative stagnation in the rural zones (0.3% per annum) are foreseen.

(*) For the present purposes, urban population was deemed to be only that residing in towns constituting the administrative centres of the municipalities.

TABLE 8.3

EXPECTED GROWTH OF THE POPULATION PER PROGRAMME - AREA

PROGRAMME AREAS	1980			1985			1990		
	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL
ALTO PARAGUAY	40 828	51 146	91 974	41 566	66 034	107 600	42 330	83 586	125 916
CÁCERES	91 270	70 608	161 878	95 086	98 734	193 820	98 969	132 918	231 887
CUIABÁ	155 224	321 947	477 171	170 597	432 280	602 877	187 280	572 886	760 166
RONDONÓPOLIS	100 568	99 841	200 409	96 519	124 548	221 067	92 272	150 779	243 152
NORTHERN SUB-REGION	387 890	543 542	931 432	403 768	721 596	1125 364	420 952	940 169	1361 121
ALTO TAQUARI	49 266	36 667	85 933	47 759	50 944	98 703	46 249	66 986	113 235
CAMPO GRANDE	53 291	299 389	352 680	46 234	373 312	419 546	39 945	457 326	497 271
BODOQUENA	45 380	49 482	94 862	44 889	61 302	106 191	44 328	74 361	118 689
CORUMBÁ	29 108	95 030	124 138	25 361	113 531	138 892	21 990	132 758	154 748
SOUTHERN SUB-REGION	177 045	480 658	657 703	164 243	599 089	763 332	152 512	731 431	883 943
UPPER PARAGUAY RIVER BASIN	564 935	1024 200	1589 135	568 011	1320 685	1888 696	573 464	1671 600	2245 064

b) Agricultural sector

From the studies carried out it can be concluded that the expansion of the surface area devoted to agriculture and planted pastures is closely related to the growth in the value of credit granted to the agricultural sector and to the extension of the road network. As mentioned in the previous section, a fall in public investment and a freezing of credit for the period 1981-85 are forecast, with moderate growth rates for both from this last year. As a result the next four years are expected to see a significant reduction in the rate of expansion of the agricultural frontier. It is estimated that this rate will be about 2.6% per annum, instead of the 12.3% registered during the 1970's. In the period 1985-90 the cultivated surface area should grow at a slightly higher rate (3.6% per annum), as a result of the recovery in the amount of credit granted to agriculture and cattle-raising and the return of public investment to normal levels.

As was seen in the seventies, the surface area under cultivation will, between 1980 and 1990, increase more in the south than in the north. This trend is due to the fact that the proportion of the cultivated area in locations with a clearly commercial orientation and therefore more sensitive to market stimuli is expected to continue being greater in the south than in the north. Thus, it is estimated that in 1990 the cultivated surface area in the north of the region will reach 771,500 ha and that of the south 935,400 ha (See Table 8.4). The greater dynamism of agriculture in the south makes it possible to predict that at the end of the present decade the agricultural frontier in the programme areas of Alto Taquari and Campo Grande will have reached its limit.

Owing to the predicted fall in the productivity of the land, agricultural production is expected to grow more slowly than the expansion of the agricultural frontier. In fact, the perspective analysis indicates that, at constant prices, the

TABLE 8.4

EXPECTED PERFORMANCE OF THE AGRICULTURAL SECTOR

PROGRAMME AREAS	SURFACE AREA UNDER CULTIVATION (1000 ha)			VALUE OF PRODUCTION (10^6 CR 1980)			DIRECT EMPLOYMENT		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
ALTO PARAGUAY	73,2	83,4	100,6	1 078,9	1 150,0	1 334,3	8 460	9 539	8 757
CÁCERES	101,8	115,7	136,6	1 557,3	1 672,3	1 902,8	12 330	13 730	9 395
CUIABÁ	134,2	153,6	184,3	2 308,6	2 515,4	2 885,9	16 389	18 827	22 450
RONDONÓPOLIS	262,6	296,8	350,0	4 044,6	4 333,2	4 943,5	27 998	26 684	23 735
NORTHERN SUB-REGION	571,8	649,5	771,5	8 989,4	9 670,9	11 066,5	65 177	68 780	64 337
ALTO TAQUARI	185,5	218,7	243,6	2 692,5	3 069,1	3 284,1	10 276	12 666	15 616
CAMPO GRANDE	387,0	437,2	527,4	5 255,5	5 535,3	6 333,9	18 174	20 543	23 846
BODOQUENA	109,6	116,2	146,4	1 623,4	1 613,0	1 932,6	6 684	6 915	7 994
CORUMBÁ	5,0	10,9	18,0	86,7	185,5	301,9	609	1 294	2 074
SOUTHERN SUB-REGION	687,1	783,0	935,4	9 658,1	10 402,9	11 852,5	35 743	41 418	49 580
UPPER PARAGUAY RIVER BASIN	1 258,9	1 432,5	1 706,9	18 647,5	20 073,8	22 919,0	100 920	110 198	113 917

value of agricultural production should grow at an average rate of 2.1% per annum during the decade. This figure is made up of a predicted increase of 1.5% per annum between 1980 and 1985 and 2.7% for the period 1985-1990. This variation in the rate of growth is due to the fact that in the first period the diminution in the productivity of the land (yields being expected to stabilize in 1985) acts jointly with the restrictions on credit and public expenditure.

From the point of view of job creation it is estimated that the region will register less progress than in the expansion of cultivation, owing mainly to the mechanization of agriculture. This process was seen to take place on a massive scale in the 1970's in the southern sub-region. Over the next few years it is likely to make a sizable impact on the northern zone. In this zone the major impact of the process of the mechanization of agriculture should be felt in the second half of the present decade, when an annual fall of 1.3% in jobs generated is expected to occur. However, at the end of the period, the labour requirements per planted hectare in the north are still likely to be 60% greater than those of the south.

The combined effect of mechanization and the diminution in the productivity of the land make it possible to predict that the behaviour of labour productivity in the north will be very different to that of the south. In the north it is estimated that there will be an average increase of 0.3% per annum between 1980 and 1985 and an annual rate of 4.2% from 1985 on. In the south, however, a substantial fall is expected in the first period (-1.4% per annum) followed by an easing of this decline (the rate rising to -0.9% per annum).

c) Cattle-raising sector

In accordance with the trends observed during the seventies the process of an increasing concentration on cattle-raising in the region is expected to continue during the present decade. In fact, a sustained increase of approximately 4% per annum in the head of cattle is expected.This average pattern implies a high degree of dynamism in the north (6.9% per annum) and very low rates in the south (See Table 8.5).

The main reason for the low rate of growth expected in the south lies in the fact that the Corumbá programme area,which accounted for 49% of the head of cattle in the southern sub-region in 1975 is at the limit of its capacity to support cattle.

The rates of expected growth of the cattle stock are higher for the period 1980-85, which coincides with the period of low growth of the areas under cultivation. These rates are consistent with historic trends, since both activities compete for the use of deforested land, with agriculture preceding cattle-raising.

On account of cattle-raising in the region being a particularly widespread activity and the existence of vast expanses of land capable of being incorporated into cattle-raising,it is assumed that the prevailing types of exploitation will be maintained. This means that the labour requirements per unit of cattle may be taken as constant for the whole period,with the consequent expectation that the growth in the number of jobs generated will be similar to that of the total head of cattle.

The value of meat production is strongly conditioned by the expected growth of the total head of cattle. However, a slightly higher rise in the value of production is expected owing to the increases in productivity. The growth rate of the value of meat production is estimated at 4.7% per annum, on average, for the decade, in comparison with the estimated 4% for the cattle stocks.

TABLE 8.5

EXPECTED PERFORMANCE OF THE CATTLE-RAISING SECTOR

PROGRAMME AREAS	CATTLE STOCK (1000 HEAD)			VALUE OF PRODUCTION (10^6 CR 1980)			DIRECT EMPLOYMENT		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
ALTO PARAGUAY	479,0	799,0	1 039,8	652,2	1 119,7	1 594,7	1 916	3 196	4 159
CÁCERES	531,6	804,7	1 189,5	747,7	1 156,1	1 738,7	2 126	3 219	4 758
CUIABÁ	1 010,0	1 406,7	1 838,6	1 472,7	2 081,7	2 773,8	4 056	5 627	7 354
RONDONÓPOLIS	1 370,0	1 931,2	2 543,7	1 920,1	2 868,7	3 848,4	5 480	7 725	10 175
NORTHERN SUB-REGION	3 394,6	4 941,6	6 611,6	4 792,2	7 226,2	9 955,6	13 578	19 767	26 446
ALTO TAQUARI	882,0	1 123,8	1 186,9	1 253,3	1 700,1	1 854,7	3 528	4 495	4 748
CAMPO GRANDE	1 026,0	1 358,4	1 444,5	1 433,6	2 403,9	2 259,5	4 104	5 434	5 778
BODOQUENA	1 548,3	1 942,1	2 229,7	2 262,4	2 923,1	3 444,6	6 193	7 768	8 919
CORUMBÁ	2 688,0	2 688,0	2 688,0	4 028,1	4 145,6	4 212,8	10 752	10 752	10 752
SOUTHERN SUB-REGION	6 144,3	7 112,3	7 549,1	8 977,4	11 172,6	11 771,6	24 577	28 449	30 197
UPPER PARAGUAY RIVER BASIN	9 538,9	12 053,9	14.160,7	13 770,1	18 398,8	21 727,2	38 155	48 216	56 643

d) Industrial sector

It is expected that industry in the region will show a high degree of dynamism in the next ten years, with an estimated average annual growth rate of 9.5%. The reasons for this optimistic prognosis are the low level of activity registered by this sector at present, the amount of investment in the projects under study and in those being implemented, and the increased activity of local industries concerned with meeting the needs of a growing urban population. Industry in the south is expected to grow at a rate of 10.2% per annum; however, the north should show growth rates slightly under 9% (See Table 8.6).

From the point of view of the structure of industrial production, a sizable expansion is forecast in the mineral processing industry, the agroindustry and the production of alcohol. These industrial branches should have growth rates of over 14% per annum.

The timber industry is expected to register a decline in absolute terms. This trend is based on the fact that this subsector is composed of very small units (with an average of less than 10 workers per business in 1975) that are engaged fundamentally in the primary preparation of native timbers. Since the timber industry is an activity resulting from the process of deforestation it is expected that it will decline to insignificant levels as this process is slowed down.

The remaining industry is composed of small firms basically engaged in supplying local markets. Thus the dynamics of this sector are strongly conditioned by the expansion of the domestic market. This fact allows one to assume that this sector of industry will experience a growth rate similar to that of the urban population, that is, about 5% per annum.

TABLE 8.6

EXPECTED BEHAVIOUR OF THE INDUSTRIAL SECTOR

PROGRAMME AREAS	ADDED VALUE (10^6 CR 1980)			EMPLOYMENT		
	1980	1985	1990	1980	1985	1990
ALTO PARAGUAY	296,6	280,6	345,6	2 011	1 808	2 267
CÁCERES	386,4	421,5	592,7	2 625	2 756	3 993
CUIABÁ	1 881,5	3 118,1	5 230,4	12 982	22 295	38 846
RONDONÓPOLIS	387,4	527,5	735,4	2 424	3 448	5 099
NORTHERN SUB-REGION	2 951,9	4 347,7	6 904,0	20 042	30 307	50 205
ALTO TAQUARI	125,1	178,6	248,5	751	1 082	1 548
CAMPO GRANDE	1 652,2	2 615,6	4 260,9	9 973	16 198	27 107
BODOQUENA	332,6	436,0	709,6	2 115	2 715	4 518
CORUMBÁ	914,6	1 552,7	2 753,2	7 604	13 563	24 937
SOUTHERN SUB-REGION	3 024,5	4 782,9	7 972,3	20 443	33 558	58 110
UPPER PARAGUAY RIVER BASIN	5 976,4	9 193,7	14 876,3	40 485	63 865	108 315

e) Construction, commerce, service industries and the public sector

The level of activity of civil construction has historically shown itself to be highly dependent upon public works (especially the building of roads) and house building. As mentioned in the previous section, a certain reduction in capital expenditure by the government is expected, which is likely in some way to affect loans for house buying. As a result, a substantial fall in the growth rate of this sector is forecast for the next ten years, with expected average growth rates of 2.3% per annum, compared with 6.5% in the previous decade. In accordance with the hypothesis concerning the behaviour of public expenditure on investment the expected growth rate for civil construction for the period 1980-85 will be only 1.8% per annum, a figure that should rise to 2.9% between 1985 and 1990 (See Table 8.7).

Adopting the historic trend of labour productivity of the construction sector at the national level (average growth of 1% per annum), one can expect that employment in this sector will grow at the rate of 1.3% per annum during the present decade in comparison with the 5.5% registered during the 1970's.

The added value of the commerce and service industries sector should show a certain fall in its historic rate of growth in the next few years, namely an expected annual rate of 6.6% in spite of the sector having grown at 10.2% per annum in the period 1970-80. This forecast is based on the slowing down of overall economic growth in the region predicted for the next few years. With regard to employment there are two opposing forecasts. On the one hand, historical trends indicate a steady increase in the average productivity of the sector, which leads to a forecast in which the increase in sectorial employment will be lower that of the product, namely 5.3% per annum (See Table 8.7). On the other hand, as the fall in the economic growth rate of the region takes effect it is highly

TABLE 8.7

EXPECTED BEHAVIOUR OF THE CONSTRUCTION, COMMERCE AND SERVICE INDUSTRIES AND GOVERNMENT SECTOR

		PRODUCT (10^6 CR$ 1980)			EMPLOYMENT		
		1980	1985	1990	1980	1985	1990
CIVIL CONSTRUCTION	NORTHERN SUB-REGION	3,559.9	3,889.3	4,480.8	24,316	25,263	27,681
	SOUTHERN SUB-REGION	1,395.0	1,524.1	1,755.9	9,527	9,899	10,846
	TOTAL	4,954.9	5,413.4	6,236.7	33,843	35,162	38,527
COMMERCE AND SERVICE INDUSTRIES	NORTHERN SUB-REGION	11,856.8	17,082.8	23,539.6	91,499	125,371	164,283
	SOUTHERN SUB-REGION	10,757.4	14,338.5	18,514.1	83,015	105,230	129,210
	TOTAL	22,614.2	31,421.3	42,053.7	174,514	230,601	293,493
PUBLIC SECTOR	NORTHERN SUB-REGION	4,356.1	5,077.7	6,206.3	22,540	24,896	29,043
	SOUTHERN SUB-REGION	7,471.9	8,709.5	10,645.3	38,664	42,857	49,818
	TOTAL	11,828.0	13,787.2	16,851.6	61,204	67,843	78,861

probable that strong pressure on the commerce and service industries sector will be generated in order to absorb the unemployment that would be brought about by this process.In these circumstances it is reasonable to assume that the average productivity will decline or at least remain constant, leading to a higher rate of employment, and that this higher growth rate would obviously give rise to a higher level of underemployment.

The public sector is also likely to reduce its growth rate as a result of the restrictions imposed on public expenditure. Thus, a growth rate of 3.6% per annum is expected in contrast to the annual rates of 16.2% registered in the previous decade. This circumstance should also affect the increase in employment, the forecast being an annual rate of only 2.6%.

f) Overall economic growth

The forecasts of sectorial trends described above allow one to conclude that the region's economy is likely to register a sharp fall in its historical growth rate, the expected annual growth rate of the gross regional product being 5.1% during the ten-year period 1980-1990. The growth of gross product should be greater in the northern sub-region than in the south, with expected rates of 5.5% and 4.6% per annum respectively.

From the point of view of the sectorial contribution to these growth rates, a highly dynamic performance is forecast for the industrial sector(9.5% per annum) followed by commerce and service industries (6.4%), agriculture being the sector of lowest growth (2.1%).

In accordance with the hypotheses on which the perspective analysis is based, the regional product is expected to grow slowly in the period 1980-85 (4.9% per annum), but is expected to quicken and reach 5.2% in the second half of the decade (See Table 8.8).

TABLE 8.8

EXPECTED SECTORIAL STRUCTURE OF GROSS REGIONAL PRODUCT
(10^6 CR - APR 1980)

	1980	1985	1990	GROWTH RATE 1980-90
AGRICULTURE	12,848.1	13,830.8	15,791.2	2.1
CATTLE-RAISING	6,100.1	8,150.7	9,625.1	4.7
INDUSTRY	5,976.4	9,130.7	14,876.3	9.5
CIVIL CONSTRUCT.	4,954.9	5,413.4	6,236.7	2.3
COMMERCE-SERVIC.	22,614.2	31,421.3	42,053.7	6.4
GOVERNMENT	11,828.0	13,787.2	16,851.6	3.6
GROSS REGIONAL PRODUCT	64,321.7	81,734.1	105,435.6	5.1
POPULATION	1,589,045	1,888,696	2,245,064	3.5
PRODUCT PER CAPITA(10^3 CR)	40.5	43.3	47.0	1.5

In spatial terms an increase in the degree of concentration of economic activity in the programme areas where the state capitals are situated is expected. In 1980 the Cuiabá programme area accounted for 50% of the product generated in the north, and this figure is expected to rise to 54% by 1990. In the case of Campo Grande, this proportion should rise from 52.3% to 53.5% in the next ten years.

The estimated growth rates of the regional product for the present decade, together with the forecasts of demographic trends, enable one to expect an increase of 1.5% per annum in per capita product throughout the region. This rate should be similar for both north and south. The per capita product is markedly higher in the south of the region and this disequilibrium is likely to persist during the period under study (See Table 8.9).

The Corumbá programme area will be the zone with the greatest per capita product in the region (77,800 cruzeiros), which is accounted for basically by its high level of cattle raising activity, the presence of mineral processing industries and the importance of the commerce and service industries sector resulting from the location of Corumbá-Ladário on the international border with Bolivia. The Bodoquena and Campo Grande programme areas will occupy second and third places, with per capita products of 58,400 and 56,300 cruzeiros respectively. The poorest programme area will be Cáceres, with an estimated per capita product in 1990 of only 31,400 cruzeiros, which is 40% of the value forecast for Corumbá.

In order to estimate the future trend of unemployment rates it was assumed at the outset that unemployed workers from the rural zones will migrate to the urban zones or leave the region altogether. Since the growth rate of the rural population is expected to be low, a fall in the underemployment in agricultural and cattle-raising activities is to be expected.

TABLE 8.9

EXPECTED BEHAVIOUR OF THE TOTAL PRODUCT AND THE PER CAPITA PRODUCT PER PROGRAMME AREA

PROGRAMME AREAS	GROSS DOMESTIC PRODUCT (10^6 CR$ 80)			PER CAPITA PRODUCT 10^3 CR$ 80)		
	1980	1985	1990	1980	1985	1990
ALTO PARAGUAY	3 345,1	4 137,7	5 238,4	36,4	38,5	41,6
CÁCERES	4 236,8	5 480,9	7 289,1	26,2	28,3	31,4
CUIABÁ	15 598,7	21 108,8	28 883,3	34,9	35,0	38,0
RONDONÓPOLIS	7 861,0	9 534,9	11 755,1	39,2	43,1	48,3
NORTHERN SUB-REGION	31 041,6	40 262,3	53 165,9	33,3	35,8	39,1
ALTO TAQUARI	3 558,4	4 492,3	5 306,5	41,4	45,5	46,9
CAMPO GRANDE	17 418,5	22 047,6	27 979,0	49,4	52,6	56,3
BODOQUENA	4 622,9	5 528,9	6 937,2	48,7	52,1	58,4
CORUMBÁ	7 680,3	9 403,0	12 046,0	61,9	67,7	77,8
SOUTHERN SUB-REGION	33 280,1	41 471,8	52 268,7	50,6	54,3	59,1
UPPER PARAGUAY RIVER BASIN	64 321,7	81 734,1	105 434,6	40,5	43,3	47,0

In the urban areas unemployment was estimated to be 6% (for 1980) throughout the region which corresponds to an unemployment rate of 9.2% in the north and one of 2.4% in the south. By 1990 the regional rate of unemployment is expected to fall slightly (with, however a widening of the gap between the north and south).

In fact, in view of the fact that the north of the region is expected to register a growth in its urban work force of 5.9% per annum and an increase in urban employment of only 5.5% per annum the unemployment rate in the towns should rise from 9.2% in 1980 to 12.5% in 1990. In practice, the most likely outcome is that this level of unemployment would be absorbed by the growth of low-productivity, marginal activities. In other words, underemployment would rise and the forecast increases in the average productivity of labour would not be achieved.

In the south the situation is different. Unemployment here is expected to disappear and, in addition, the average productivity of labour is expected to increase at the rate of 0.8% per annum, in comparison with the 0.4% postulated initially.

8.2 MAIN FEATURES OF THE PROPOSED STRATEGY FOR PROMOTING REGIONAL DEVELOPMENT

In the diagnosis the region was characterized as a zone recently incorporated into the national economic space that over the previous decade registered a high economic and demographic dynamism. The kind of development experienced by the area , despite its efficacy in stimulating considerable economic growth, has generated quite serious problems that threaten to nullify its dynamism in the short or medium term.

This fact, allied to the current policies limiting public expenditure and reducing credit facilities, makes it clear why the perspective analysis predicts a marked fall in the growth rate of the regional economy over the next few years. This obviously has serious implications, both from a socio-economic viewpoint and in relation to the role that the area should play in the context of national and regional development.

In these circumstances the proposals formulated by EDIBAP for the development of the region are part of an overall strategy that postulates internalizing to the area the dynamic factors that account for its recent development and establishes a set of criteria and specific measures intended to check the negative effects of this process.

A strategy for regional development should contain a set of criteria that will orientate the adoption of specific decisions for attaining a previously determined "goal image".As such, the formulation of a strategy for the development of the Upper Paraguay River Basin calls for the adoption of a theory that will account for the structure and functioning of the region in question, as well as a set of normative judgements that will determine what this structure and its functioning should be. These elements should permit the identification of those variables that need to be controlled in order to ensure the attainment of the goals, as well as the form or intensity in which such control should operate.

In view of the markedly "primary exporting" character of the region's economy and bearing in mind that national development policies ascribe to the region the role of a zone functioning as a supplier of food and raw materials, it seems reasonable to adopt the theory of the economic base as the interpretati ve and explicati ve element of its present and future behaviour. This means that regional development is understood as a func tion of the performance of the export sector(i.e. agriculture, cattle-raising and mining), which plays a fundamental part in the determination of the absolute and per-capita income of the region and, therefore, in determining the amount of resi dential activities (secondary and tertiary) that will be deve loped in the region.

The normative judgements for their part are expressed in a set of objectives and goals, and also in criteria pertaining to their form and the time scale for their attainment. In or der to ensure the viability of the strategy the objectives should be compatible with national and regional development policies and should, in addition, be strictly within the ins titutional capacity of the entities responsible for the imple mentation of the policies and actions designed to further the pursuit of such objectives.

These basic concepts lead to the selection of a limited set of actions intended to dynamize the functioning of the socio-economic system of the Upper Paraguay River Basin with the aim of attaining the goals described in section 8.2.1.

It is important to stress that the proposed strategy does not claim to act on all aspects of the regional system. In fact, the strategy is highly selective and is intended to perform only a limited number of actions, which were chosen by reason of their capacity to generate positive and complementary reactions in the regional system. In this way the viability of the strategy is increased and its implementation should cause a significant and generalized impact on the whole range of socio-economic activities in the region.

8.2.1 Functions of the region in the national-regional context and goals of the strategy.

The directives emanating from the III National Development Plan and the prevailing regional development policies make it possible for the region of the River Basin, at least in the medium term, to fulfil the important functions in the development of the country, indicated below:

a) Supply substantial quantities of foodstuffs for the Brazilian market, raw materials, agricultural produce for export, minerals and forestry products;

b) Act as a receiver area for contingents of small and medium-size farmers from other regions of the country, since it possesses sufficient areas well suited to agriculture conveniently situated in relation to the networks of transport, storage, service centres, fertilizer supplies and trading centres;

c) Act as a frontier for the expansion of the activity of farmers and cattle-breading entrepreneurs from the neighbouring state of Paraná and São Paulo, which have practically exhausted their own internal agricultural frontiers;

d) Act as a logistic base for the incorporation and selective occupation of the Brazilian Amazon region and for the consolidation of national sovereignty over a wide area of international border.

In order to fulfil these functions regional planning for the Upper Paraguay River Basin should satisfy two types of objectives: on the one hand, those expressed in terms of sectorial, overall, quantitative results, basically evaluated by the increase in production and income; on the other, those involving differentiated aspects and which determine a specific role to be played by the region in the context of the country.

In terms of overall and sectorial development the ability of the region of the Upper Paraguay River Basin to meet national and regional objectives is mainly dependent upon the growth potential of the agriculture and cattle-raising activities and the harnessing of water resources. Its ability to do this enables the region to make a useful contribution to the government's two major sectorial priorities: an increase in the national production of food and of renewable sources of energy.

From these elements are derived the following specific objectives of the strategy of development:

I Economic growth

i) Maintain high growth rates of the regional product, stimulating in particular the production of foodstuffs and minerals.

ii) Increase the degree of inter-sectorial integration of the regional economy by strengthening industry engaged in the processing of local raw materials.

iii) Reduce the external dependency of the region by strengthening the competitiveness of local entrepreneurs.

iv) Achieve, in the medium term, an equilibrium in regional electricity supply and demand and increase the export of energy products derived from the harvesting of vegetal biomass.

II Social development

i) Improve the population's access to the basic services of health, education and sanitation.

ii) Increase job opportunities in order to reduce the present levels of unemployment and absorb part of the streams of migrants.

iii) Reduce social inequalities in the rural areas through the incorporation of small land owners and subsistence farmers into a market-orientated form of agriculture.

III Improvement of the environment and spatial development

i) Succeed in using the natural resources in accordance with their potential, with special emphasis on the ecological equilibrium of the Pantanal and the preservation of the fertility of the soils in the region.

ii) Improve the region's internal and external accessibility in such a way as to enhance its interaction with the Central West region and the rest of the country.

iii) Streng then the system of urban centres.

In order to attain these goals the strategy of development proposes a set of actions that can be subsumed in three basic policies; these are: a policy designed to strengthen and dynamize the regional economic structure; a policy of social development; and a policy of spatial character.

In accordance with the guidelines of the government and the terms of the technical co-operation agreement that gave rise to EDIBAP the proposed strategy gives priority to stimulating regional economic growth and in addition, intends to carry out specific actions to solve the region's social problems and improve its spatial organization.

8.2.2 Content of the strategy

The strategy defines the future orientation of the process of regional development and indicates both the philosophy that should characterize the entities responsible for the implementation of specific actions and projects, and the kind of instruments to be used in the pursuit of the goals. As such, the strategy contains guidelines of a general nature whose specification is effected in the programmimg (see Appendix II), where the investment projects and actions to put them into effect are identified and chronologically ordered.

A Measures designed to stimulate regional economic growth

Rural and mining activities having been recognized as constituting the economic base of the region, attention should be concentrated on making these sectors function more dynamically and on the branches of industry directly linked to them. In accordance with the suggested interpretative theory it is assumed that the remaining sectors of the economy will evolve according to the growth rates experienced by the export activities.

In these circumstances regional development should be based on an increase in the efficiency and level of activitiy of its primary sectors, accompanied and sustained by a process of industrialization initially linked to these sectors.

In accordance with what has been outlined above the strategy postulates:

i) Fostering the development of agriculture and cattle-raising by:

- The expansion of the surface area incorporated into production, observing the physical and ecological limits of exploitation of the existing natural resources.

- Changing the structure of production by introducing the rotation of crops and cattle-raising activities. This in addition to the rise in the value of production that results from a better use of the existing productive capacity, should lead to an increase and stabilization of the land's productivity.

This process of expansion of the surface area exploited and change in the structure of production will be given impetus by the reorientation and strengthening of the official programmes of support for rural production, particularly those concerned with roads, storage, agricultural experiments, technical assistance and credit facilities.

In view of the existence of large numbers of small producers who are not in a position to respond to stimuli channelled through market mechanisms, specific actions intended to increase and diversify production and improve incomes in the sectors of small properties and subsistence farmers are considered.

All these elements, together with the previously mentioned specific support projects, make up the programme of agriculture and cattle-raising development that will contain various kinds of technical and productive solutions designed for prototype farms.

ii) Solving the supply problems of electric power so as to permit the development of significant mining projects, especially iron and manganese (Corumbá area) and cement and calcareous deposits (Bodoquena and Nobres).

By its very nature, the enlargement of the region's capacity to produce electric power can only be achieved in the medium term.
This implies that the mining sector should show moderate growth rates in the short term.
Despite this limitation the strategy postulates an increase in the production of agricultural calcareous substances in order to meet, at least, the growing demands from the region's rural activities.

iii) Accelerating the process of industrialization in the area, giving special emphasis to the creation of an agroindustry which, in addition to stimulating primary production by means of a stable demand, will increase the added value of local exports.

This process should also present a "controlled" substitution of regional imports, preferably orientated to the production of inputs for the primary sector.

The specific projects for the development of the industry are to be identified on the basis of the need to process the present and projected rural production as well as of the need to supply inputs for such activities, the kind of economic policy instruments necessary to ensure their implementation being indicated in each case.

These instruments should be accompanied by specific measures designed to favour local entrepreneurs and encourage people from other states to settle in the area, thus preventing the drain of income and capital that leads to a reinvestment of profits in other regions which is the normal practice for national or multinational companies.

B Measures for fostering social development

Although the main emphasis of the strategy is on stimulating the economic growth of the region, a series of social problems is recognized and measures are therefore proposed to solve or attenuate them.

These measures are chiefly concerned with the provision of basic health, education and sanitation services, in addition to requiring that the economic sectors create sufficient jobs to absorb unemployment and avoid the "marginalization" of large sections of the population, especially in the rural areas.

Even when, what are, strictly speaking, social actions include some physical investments (schools, health posts, sanitary facilities, etc) it becomes more important than ever to improve the quality of the basic services at the disposal of the population.

This necessarily entails substantial changes in the operational level of the public bodies responsible for providing such services.

In specific terms the strategy postulates:

i) Improving the quality of health services and making them more widely available. This will be achieved by

- training staff;
- building health posts in rural districts and making them operational;
- building health centres and mixed units in the administrative centres of municipalities and making them operational.

ii) Extending the area covered by the water supply systems in medium-sized urban centres and setting up water supply and sewage disposal systems in 53 rural districts.

iii) Extending the coverage and improving the quality of education services. Owing to the region's low educational standards this action should be concentrated primarily on basic education in rural districts and secondly on the upper levels of urban schools. To this end the following is proposed:

- construction and equipping of educational establishments;
- training and preparation of teachers for rural schools;
- bringing the curricula up to date in both primary and secondary education;

C Measures for preserving the environment and improving spatial organization

The strategy postulates an ordering of the utilization of geographic space that will make the ecological equilibrium compatible with an increased intra and interregional accessibility.

As far as the preservation of the ecological equilibrium is concerned, the strategy foresees the need to guarantee increased levels of land productivity. This implies a policy designed to integrate agriculture and cattle-raising by means of a rotation of crops and pastures, the duration of each being determined according to the quality of each type of soil. This policy is expressed in qualitative criteria that operate through the instruments for the implementation of the programme of agricultural and cattle - raising development.

In spatial terms, it is intended to reconcile a relatively dispersed pattern of settlement of the population and economic activity (made necessary by the fact that agriculture and cattle-raising are the central elements in the development strategy) with the infrastructure requirements that make it necessary both to meet the needs of rural population and to provide the inputs for agriculture and cattle-raising and put production on a commercial footing.

In specific terms, it is proposed to:

i) Strengthen the system of urban centres by raising the standard and increasing the variety of the services provided by the second and third level urban centres, and improve communication systems so as to permit a more effective integration of the different urban centres with each other and, individually, with their respective areas of influence.

In particular, the strategy foresees the need to give special attention to the small units that have been defined as the main urban centres of their programme-areas (Tangará da Serra, Jardim and Coxim), together with measures to raise the quality of the services and infrastructure in the medium-sized towns (Corumbá/Ladário, Rondonópolis, Cáceres and Aquidauana/Anastácio).

ii) Improve and extend the road network so as to permit a greater freedom of movement on the existing road network and effect an improvement in the region's internal accessibility. Investment in roads is a pre-requisite both for attaining the goals in rural production and for solving social problems. For this reason the selection of networks for improvement and construction was made in accordance with the increase in traffic forecast as a result of the production programmes and estimates of population.

In this way the strategy postulates concentrating investment in the priority zones for agricultural development, which in its turn implies favouring the improvement of the existing network, and only in exceptional cases will new roads be built.

iii) Co-ordinate and make compatible the sectorial projects and actions at the subregional level (programme-areas) by means of a set of criteria for defining the siting of the productive projects, infrastructure and basic social services.

Although this is only a proposal of a methodological nature, its inclusion in the strategy is justified for two main reasons. In the first place, it is a means of explicating the policy of land organization entailed by the proposed measures. On the other hand, this stage of compatibilization and coordination is a distinctive element of the strategy.

In fact, the proposed measures were selected from among a relatively large number of possible options and constitute a minimum, indispensable set of actions required for attaining the goals. Given that the strategy assumes that the impact of the implementation of the set of measures is markedly greater than the sum of the individual impact of each of these options and projects, the pursuit of the desired effects makes the co-ordination of their implementation imperative at the programme-area level.

8.3 EXPECTED IMPACT OF THE PROPOSED STRATEGY

This section contains estimations of the probable effect to be expected in the regional system from the implementation of the strategy presented in Section 8.2. Since strategies are usually defined in broad terms (see Section 2.3) their evaluation is quite complex due to difficulties inherent in the quantification of the effects derived from policies formulated in too general terms. In fact, any policy can be implemented through a wide range of projects and specific actions. Thus, in order to avoid this problem the proposed strategy is understood as specified by the set of investment projects and programmes of public action summarized in Appendix II.

For the purposes of analysis it is assumed that the actions and plans will be carried out in the form and within the time-scales that were forecast, their implementation being understood as starting as early as 1982.

As explained, the strategy is intended to act on a limited set of selected variables, in accordance with their capacity to stimulate the growth of the whole regional socio-economic system. In this way EDIBAP's proposals are complementary to the normal policies and plans of the state governments and federal agencies. Thus, the evaluation of the impact of the proposed development plan should be made by comparing the regional situation expected as a result of the plan with that forecast in Section 8.1.

8.3.1 Economic impact

In economic terms the proposals formulated by EDIBAP are intended to raise the standard of efficiency of the region's basic sectors (agriculture and cattle-raising), improve the intersectorial integration of its economy and improve the region's degree of competitiveness in the national context.

These improvements should be manifested in the form of higher levels of production and productivity, a reduced degree of dependency on the part of the regional economy in relation to extra-regional factors, and more stable growth rates. For greater accuracy the sectorial impact of the plan will be analysed first, after which its contribution to the overall economic growth of the study area will be evaluated.

a) Agriculture and cattle-raising

The proposed models for rural production postulate a greater integration of crops and the breeding of cattle in such a way as to ensure, on the one hand, a land use compatible with the limitations imposed by the ecological equilibrium and, on the other, the introduction of organic matter into the soils in order to raise their productivity. This technological conception is complemented by increases in the surface area under cultivation, in planted pasture and in the total stock of cattle.

In order to achieve these goals it is intended that during the first five years about 22.7% of producers in the study area should adopt the proposed technology, investing a total of 25,232.8 million cruzeiros (at 1980 prices) in increasing the productive capacity of their establishements as well as increasing by 23,720 millions their normal operating costs. In view of the obvious benefits to every producer resulting from the adoption of the proposed technologies it is expected that after the first five years the number of producers introducing the aforementioned technology will progressively rise to about 35% in 1990. This proportion of producers should cover about 59% of the cultivated surface area and 48% of the region's head of cattle.

i) Productivity

The proposed production models assume significant increases in productivity, in both agriculture and cattle-raising. In the case of the agricultural sector the increased productivity should be the result of a better selection of lands intended for crops, the materialization of the planned investment in soil improvement, and the use of the recommended inputs. These three elements should lead to substantial production increases per hectare, which should vary from 33.4% in the case of rice to 105.2% in the case of maize (see Table 8.10).

TABLE 8.10

PRESENT AND PLANNED AVERAGE YIELDS OF THE MAIN CROPS (KG/HA)

CROPS	PRESENT YIELD	PLANNED YIELD	% INCREASE
RICE	1288	1719	33,4
SOY	1557	2190	40,6
MAIZE	1548	3177	105,2
BEANS	612	912	49,0
COTTON	967	1752	81,2

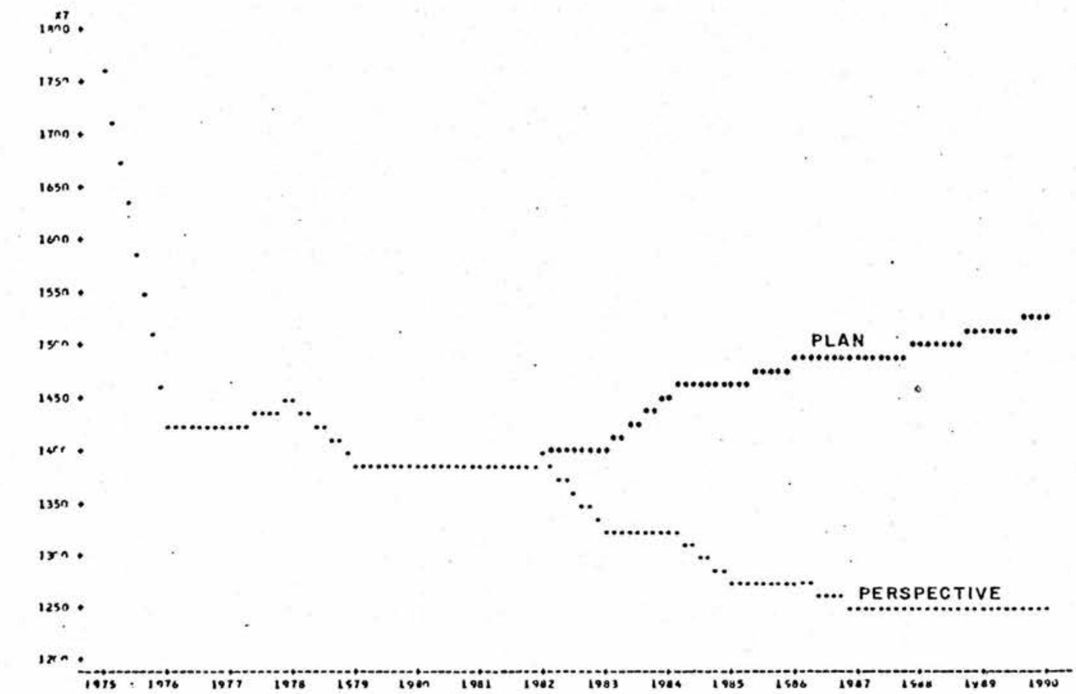
With regard to annual crops, the planned yields are likely to be reached in the harvest following the adoption of the technical recommendations, and their effects are permanent as long as the suggested production practices are maintained.

In this way the impact that the planned technologies will have on average productivity in the region depends on the speed with which farmers come to adopt the new forms of production.

EDIBAP intends that about 46.5% of the cultivated surface area should, in the first five years of the implementation of the projects, incorporate the recommended technologies; it is also expected that in the remainder of the present decade this proportion will rise to 58.5%. The attainment of these goals should mean, in the case of rice alone, an increase in the region's average productivity of over 20%, thereby reversing a downward trend, in a process of continuous increases in yields (see Fig. 8.5).

Figure 8.5

EVOLUTION OF YIELDS OF RICE (kg/ha)



The impact of technological change on the volume of production will be quite substantial; if the planned measures are carried out the physical volume of rice production in 1986 will be 110,000 tons greater than what would be obtained over the same cultivated area through the application of current technologies. This increase in rice production, resulting from increases in productivity, would be equivalent to an 88,000 hectares extension of the surface area devoted to this crop if the yields forecast in the perspective analysis are maintained.

In the case of cattle-raising, it is expected that the establishments that come to adopt the proposed forms of production will increase the productivity of the cattle stock by 163.4%. This means that their production of 16.4kg of meat per annum per animal will rise to 43.2 kg. This increased productivity will be achieved as a result of the consolidation of the activity of fattening, which implies that the average time that the cattle remain in the region will be greater than before.

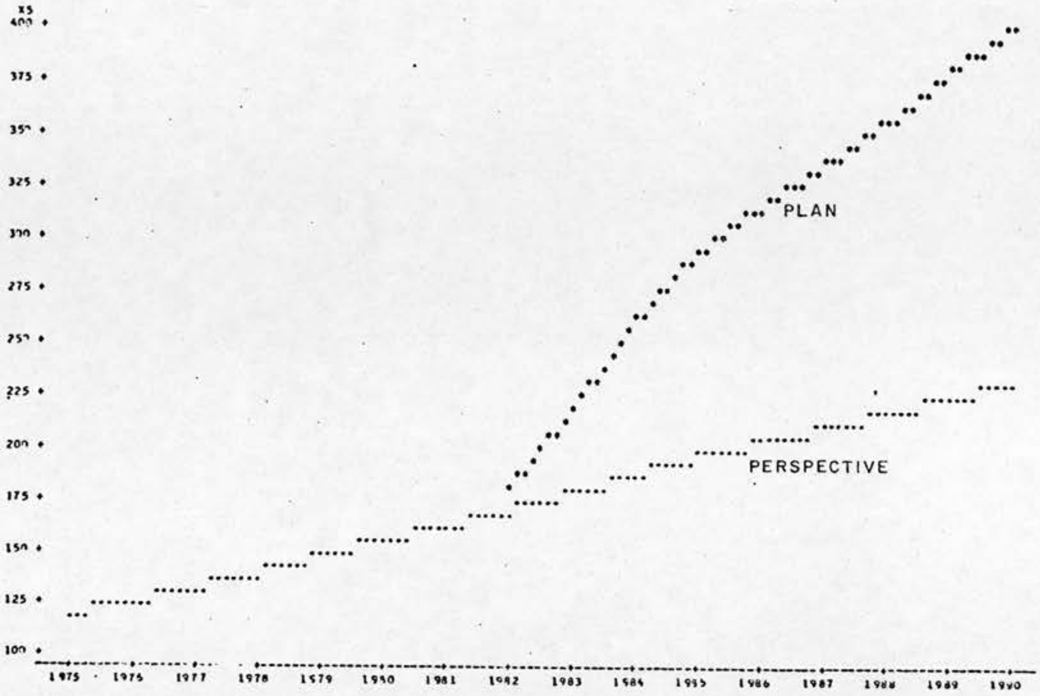
As the number of producers who will incorporate the recommended technologies should progressively increase, reaching 35.7% of the total head of cattle in the region in 1985 and 47.7% in 1990, the expected growth of the average regional yields should lead to a production of 29.6kg of meat per animal by the end of the present decade. This would mean an annual growth rate of 7.7% (see Fig. 8.6).

ii) Surface area under cultivation

Historically, the performance of the area under crops and that devoted to artificial pasture has been closely related to the extension of the road network and the expansion of credit for agriculture and cattle-raising.

Figure 8.6

EVOLUTION OF BEEF PRODUCTION (10^3 TONS)

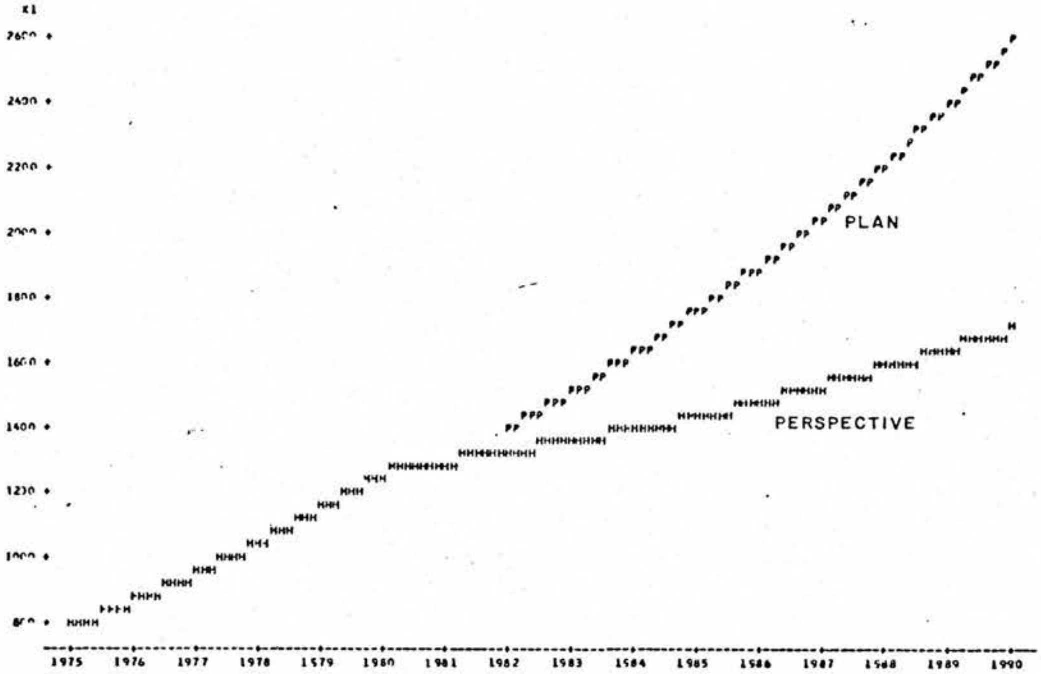


Since the perspective analysis was based on the hypothesis of a restriction on public expenditure and a virtual freezing of credit for agriculture and cattle-raising, it was estimated that the surface area under cultivation would grow at a rate of 2.6% per annum between 1980 and 1985 and at about 3.6% between 1985 and 1990.

The implementation of the plan proposed by EDIBAP assumes both special increases in credit for agriculture and cattle raising and an extension of the region's road network. Consequently, the growth rate of the surface area under cultivation should increase to 7.1% per annum during the first five years of the implementation of the plan, and thereafter stabilize at 5% per annum. In this way the implementation of the plan should mean an increase of 341,400 hectares under cultivation over the perspective forecasts for 1985, a figure which should be much higher by 1990. It is expected that the total surface area under cultivation with the recommended technologies will reach 743,300 hectares in 1985 and 1,325,000 hectares by the end of the decade (see Fig. 8.7).

Figure 8.7

EVOLUTION OF LAND DEVOTED TO CROPS (ha)



iii) The cattle stock

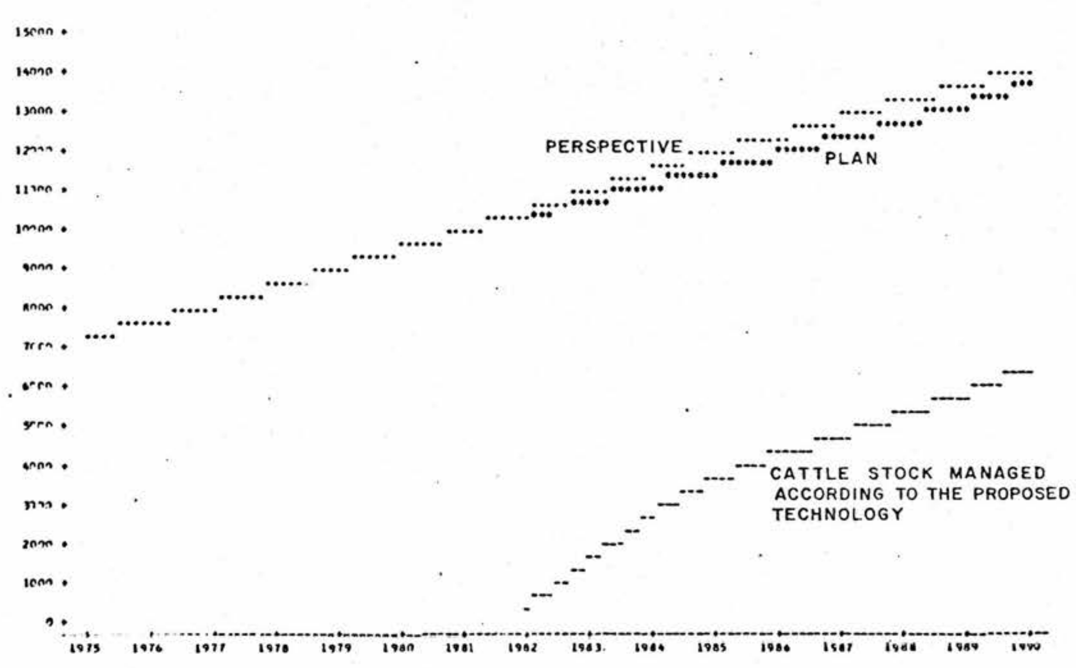
The cattle-raising programme is intended to modify substantially the structure and level of activity of this sector through the consolidation of the activity of fattening, improvement of the animal -planted pasture relationship, and increases in the productivity of the natural pasture .

The stimulus to be given to the fattening of animals aims to bring about a more intensive use of the existing planted pasture , introduce a highly profitable activity, and increase the added value of regional exports. This entails reducing the removal of insufficiently developed animals, lengthening the period in which cattle remain in the region and bringing about a fall in the growth rate of the existing herds.

In fact, the region's cattle stock is expected to grow at an annual rate of 3.5% during the present decade, as compared to the 4% forecast in the perspective analysis. This fall in the growth rate of the cattle stock will be amply compensated for by the increases in productivity that the proposed measures should generate, with the physical production of meat in 1985 expected to be 48.8% higher than the estimates of the perspective analysis, a percentage that is likely to rise to 73.2% by 1990. The planned physical production will therefore increase at an annual rate of 9.9% during the period 1980-1990, as compared with the 4.7% forecast (see Fig. 8.8):

Figure 8.8

EVOLUTION OF THE STOCK OF CATTLE (1000 ANIMALS)



iv) Rural product and employment

In accordance with the aforementioned antecedents, the regional agricultural product is expected to grow at 8% per annum during the present decade and the cattle-raising product is likewise expected to increase at 10.5 per annum. These figures greatly exceed the estimates of the perspective analysis which indicate annual rates of 2.4% for the agricultural product and 4.7% for the cattle-raising product.

In the agricultural sector this change in the expected growth rates is accounted for mainly by increases in the surface area under cultivation (75.5% of the increase forecast for the product) and, to a lesser extent, by increases in productivity. In the case of cattle-raising the improved performance is based on a transformation of the mode of cattle-raising, implying great increases in the average productivity of the cattle stock and a slight decline in its growth rate.

Employment generated by agriculture should grow at a rate of only 3.7% per year, as a result of the increases in labour productivity brought about by the introduction of the proposed production models. In the case of cattle-raising it is assumed that the labour-cattle relationship will be maintained, which would lead to a growth in employment at a rate similar to that of the cattle stock (see Table 8.11).

b) Industrial sector

The proposed development strategy postulates accelerating the process of industrialization in the region through the creation of a dynamic and efficient agroindustry preferably orientated to markets outside the region.Accordingly, the industrial projects identified by EDIBAP are concentrated on what was termed "regional export industry", which

TABLE 8.11

EXPECTED GROWTH OF THE LEVEL OF ACTIVITY OF THE AGRICULTURE AND CATTLE-RAISING SECTOR

		1980	1985		1990	
			PERSPECTIVE	PLAN	PERSPECTIVE	PLAN
AGRICULTURE	SURFACE AREA UNDER CULTIVATION (1000 HA)	1,258.9	1,432.5	1,773.9	1,706.9	2,264.0
	ADDED VALUE 10^6 CRUZEIROS 1980	12,848.1	13,830.8	19,009.3	15,791.2	27,727.1
	DIRECT EMPLOYMENT	100,920	110,198	130,048	113,917	145,733
CATTLE-RAISING	CATTLE STOCK (1000 ANIMALS)	9,538.9	12,053.9	11,373.0	14,160.7	13,507.6
	ADDED VALUE 10^6 CRUZEIROS 1980	6,100.1	8,150.7	12,397.5	9,625.1	16,515.1
	DIRECT EMPLOYMENT	38,155	48,216	45,492	56,643	54,030
TOTAL	ADDED VALUE 10^6 CRUZEIROS 1980	18,948.2	21,980.7	31,406.8	25,416.3	44,242.2
	DIRECT EMPLOYMENT	139,075	158,414	175,540	170,560	199,763

is concerned with the the processing of products derived from agriculture and cattle-raising. The expansion of the production of calcareous substances is likewise recommended.

The implementation of the industrial development proposals formulated by EDIBAP should have a considerable impact on the regional economy since they will affect the kind of activity for which the region has a high potential and which is at present found at very low levels of operation.

In fact, the set of selected projects should lead to an expansion of productive capacity equivalent to about 79% of the level of activity of the whole of the region's industry forecast for 1990. In the case of export industry the proposed projects signify the introduction of a productive capacity capable of generating in 1990 a production four times greater than that estimated for that year in the perspective analysis.

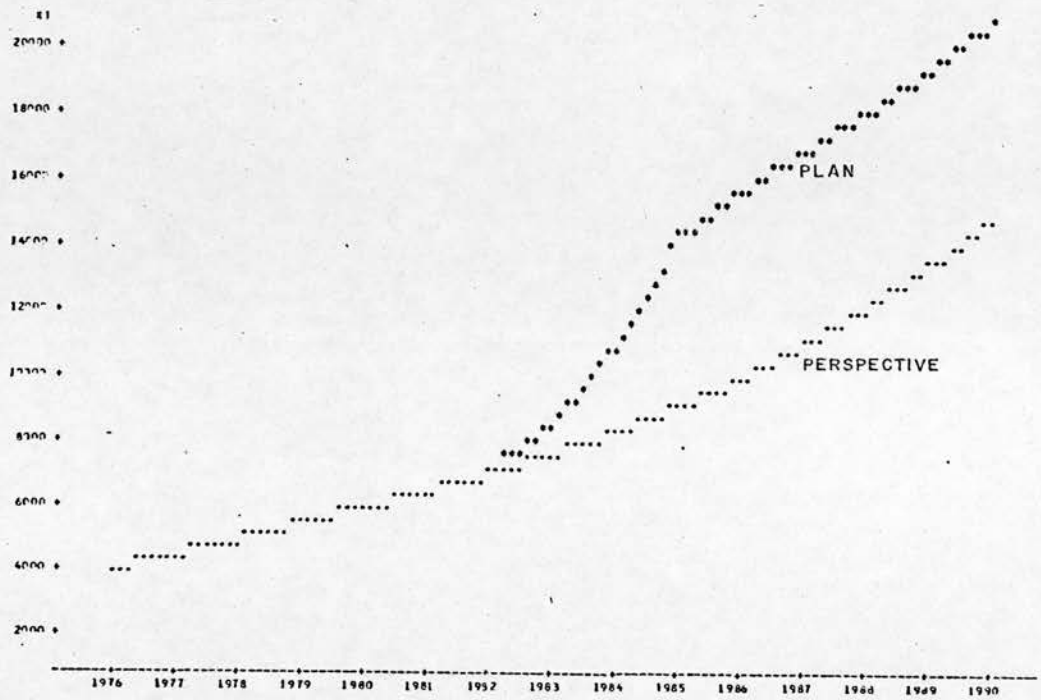
The projects were defined in such a way as to ensure their adaptation to the real situation of the region, both as regards the availability of raw materials and in relation to its technological and operational levels. Although these elements in themselves guarantee the viability of the projects, for the purposes of evaluating the economic performance of the region it was assumed that the aforementioned projects would operate at 60% of their capacity, a level that would in itself guarantee real profits for private industry.

In this way, as a result of the implementation of the plan a significant rise in the growth rate of the region's industrial product would be observed, reaching 13.3% per annum between 1980 and 1990, well above the 9.5% forecast (see Fig. 8.9).

In addition to the quantitative impact, the effects of the implementation of the selected projects should lead to an

Figure 8.9

EVOLUTION OF INDUSTRIAL PRODUCT (10^6 CR - 1980)



increase in the productivity of the industrial labour force and to a greater integration of the regional economic system. With regard to the productivity of the industrial labour force it is expected that export industry will double the yield of its work force between 1982 and 1990 and that the mining sector will show a growth of about 10% in the same period.

The greater integration of regional industry with the agricultural and cattle-raising activities should, for its part, contribute to farmers obtaining higher and more stable prices and to the stimulation of other secondary and tertiary activities.

In terms of employment the proposed industrial projects will mean the creation of almost 10,000 new jobs, corresponding to an increase of 8.8% in relation to the employment forecast for 1990.

Moreover, as the proposed projects should be preferably loca ted in second and third level urban centres the employment generated by them should be a highly important element in the consolidation of a more balanced system of urban centres.

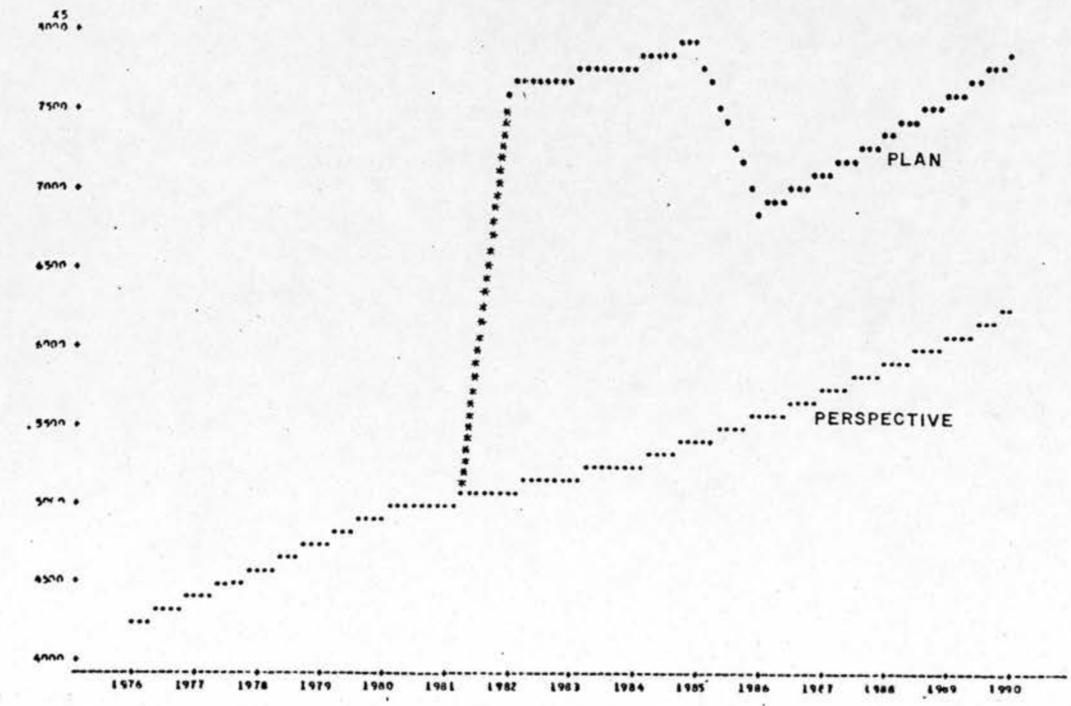
c) Construction, commerce, service industries and public sectors

The development strategy does not contain any specific measu res intended to stimulate the growth of these sectors in the region, but the implementation of the measures proposed will inevitably lead to an increase in their level of activity.

Civil construction should feel the impact of the programmes for extending the road network, building schools and factories, increasing the number of health units, supplying drinking water, etc. This should mean a rapid growth in the year when the construction work begins, followed by smaller increases throu ghout the period of execution. (see Fig. 8.10)

Figure 8.10

EVOLUTION OF CIVIL CONSTRUCTION PRODUCT
(10^6 CR\$ - 1980)

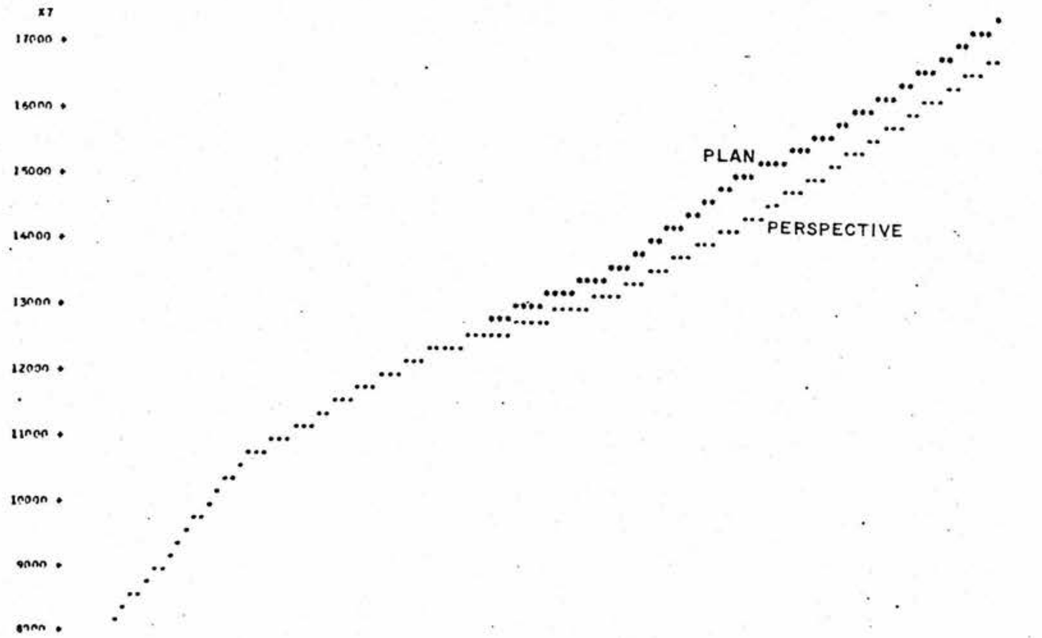


Once the construction of the planned works has been completed the level of activity of this sector should fall to its new level of normal activity. This will be greater than had been forecast in the perspective analysis for the increase in overall production that will be brought about as a result of the implementation of the plan.

The activity of the public sector should increase both as a result of the higher level of economic activity forecast for the area and through the proposed expansion of the health services, education, technical assistance, public works, etc. This sector is thus expected to register average growth rates of 3.9% per annum as compared with the 3.6% forecast in section 8.1 (see Fig. 8.11)

Figure 8.11

EVOLUTION OF GOVERNMENT SECTOR'S PRODUCT
(10^6 CR$ - 1980)



In the case of commerce and service industries, even though the strategy does not envisage any specific projects to make them function more dynamically, a higher level of activity is expected as a result of the increases in regional added demand generated by the growth of agriculture, cattle-raising and industry and by the proposed investments. Thus it is estimated that the commerce and service industries sector should increase its annual growth rate from the 6.4% forecast to 7.5%.

d) Overall economic impact

The implementation of the strategy assumes that within a five-year period 57 billion cruzeiros (April 1980) will be invested in the region as an increase in fixed capital. Of this total 66% consists of directly productive investment in the agricultural, cattle-raising and industrial sectors. The rest comprises investment in physical infrastructure (roads, electric power, urban equipment) and in the provision of basic services (health, sanitation and education).

The public sector is expected to contribute with 19 billion cruzeiros worth of physical investments and to create the conditions needed for financing the investments to be made by the private sector. These conditions include increasing the normal credit lines for investment in agriculture and cattle-raising by 17.4 billion cruzeiros and those for investment in storage facilities by 2.5 billion cruzeiros; credit for industry is to increase by 5.2 billion cruzeiros and loans worth 1.4 billion cruzeiros are to be granted through the mechanism of financial incentives.

The investments to be financed by the private sector from its own resources in the next five years are expected to amount to 10.8 billion cruzeiros.

Obviously, to this sum must be added the payment of the above mentioned loans (granted through official agencies) for achieving the forecasted 37.6 billion cruzeiros worth of private investment.

This input of resources should produce a very big impact on the regional economy, which can be accounted for both by the enormous size of the proposed investments and by the high proportion that they represent in comparison with the present levels of economic activity in the region. In fact, direct productive investments to the value of 37.6 billion cruzeiros are proposed in circumstances where the regional product is estimated at 64.5 billions for 1980. If the impact of the investments in infrastructure and social services are added to this it is possible to foresee that the regional product should more than double in the period 1980-1990.

In accordance with the perspective analysis, the regional economy was expected to grow 4.9% per annum between 1980 and 1985 and 5.2% between 1985 and 1990, which means an average growth rate of 5.1%. The implementation of the plan should lead to an average growth rate of the regional product of 7,8% per annum during the present decade. As the investments will be concentrated in the first few years the growth rate for the period 1980-85 is expected to rise to 9.4% per annum, a rate that should fall to 6.3% between 1985 and 1990. This decline in the growth rate is explained by the fact that after the fifth year the extraordinary flow of resources that occurs whenever projects are being implemented and starting to function should come to an end, in addition to which it is natural that growth rates should fall with higher levels of economic activity.

Since the productive investments are concentrated in agriculture, cattle-raising and industry it is natural that the dynamism of these sectors should increase substantially. In fact, the industrial sector is expected to grow at 13.3% per annum, cattle-raising at 10% per annum and agriculture at 8% per annum (see Table 8.12).

TABLE 8.12

EXPECTED GROWTH OF THE REGIONAL ECONOMY ADDED VALUE (10^6 CR-APRIL 1980)

	1980	1985		1990	
		PERSPECTIVE	PLAN	PERSPECTIVE	PLAN
AGRICULTURE	12,848.1	13,830.8	19,009.3	15,791.2	27,727.1
CATTLE-RAISING	6,100.1	8,150.7	12,397.5	9,625.1	16,515.1
INDUSTRY	5,976.4	9,130.7	14,212.5	14,876.3	20,744.7
CIVIL CONSTRUCT.	4,954.9	5,413.4	7,923.3	6,236.7	7,815.3
COMMERCE-SERVIC.	22,614.2	31,421.3	32,920.0	42,053.7	46,739.1
GOVERNMENT	11,828.0	13,787.2	14,289.8	16,851.6	17,358.4
GROSS REGIONAL PRODUCT	64,321.7	81,734.1	100,752.4	105,434.6	136,899.7
POPULATION	1,589,045	1,888,696	1,995,445	2,245,064	2,505,783
PRODUCT PER CAPITA (10^3 CR)	40.5	43.3	50.5	47.0	54.6

The level of employment should grow at lower rates than that of the regional product by virtue of the increases in productivity associated with the development Plan. It is predicted that between 1980 and 1985 regional employment will grow at 6.7% per annum and at an average rate of 5.2% per annum throughout the decade. These rates are higher than the annual 4.4% forecast in the perspective analysis, which means that 55,000 jobs more than the number forecast in that analysis should be created in the region as a result of the implementation of the Plan.

The industrial sector should be the most dynamic one in the creation of jobs; employment in industry is expected to grow at an average annual rate of 11% during the decade, which entails almost trebling employment in industry by 1990 (see Table 8.13).

Since the expected growth rate of employment is greater than the increase in the work force, it is reasonable to assume that the demand for labour will create suitable conditions for an increased migration to the region (see subsection 8.3.2).

As a result of the great dynamism that the regional economy should undergo, not only is the population growth of the region expected to expand but also its per capita product is expected to increase significantly.

The perspective analysis estimated a 1.5% average growth rate of the per capita regional product during the period 1980-1990. The implementation of the plan should make the average rate rise to 3% per annum between 1980 and 1990.

TABLE 8.13

EXPECTED GROWTH OF REGIONAL EMPLOYMENT

	1980	1985		1990	
		PERSPECTIVE	PLAN	PERSPECTIVE	PLAN
AGRICULTURE (*)	100,920	110,198	130,048	113,917	145,733
CATTLE-RAISING(*)	38,155	43,216	45,492	56,643	54,030
INDUSTRY	40,485	63,865	90,069	108,315	117,879
CIVIL CONSTRUC.	33,843	35,162	48,946	38,527	43,763
COMMERCE-SERVIC.	174,514	230,601	236,614	293,493	297,508
GOVERNMENT	61,204	67,843	70,316	78,861	81,186
TOTAL	449,121	555,885	621,485	689,756	745,099

(*) Includes only direct employment

8.3.2 Social impact

As explained in the previous chapters the measures and projects included in the Development Plan represent a strategy that is chiefly devoted to stimulating regional economic growth and proposes a number of specific actions to solve certain problems of a social nature.

Even though social development does not constitute the specific goal of the strategy its implementation should bring about considerable changes in the structure and functioning of the regional socio-economic system. Thus the social impact of the proposed actions cannot be properly evaluated without taking into consideration both the expected effect of the education, health and sanitation programmes and the social effects of the forecast changes on some economic variables.

Traditionally, the literature on regional analysis attributes a very important role to migratory flows as an explanatory element of the demographic dynamics of regions, and to the incidence of economic growth in the speeding-up of these flows.

The studies undertaken by EDIBAP allow one to conclude that between 1960 and 1970 about 37% of the region's population growth is accounted for by net migration, a process which, during the period in question, involved around 260,000 persons in the states of Mato Grosso and Mato Grosso do Sul.

In order to account for the pattern of net migration at the sub-regional (programme-areas) level a model was constructed relating the rates of migration to the growth rates of employment (see Chapter 4).

Given that, as a result of the plan, an increase in the growth rate of employment is forecast (5.2% per annum as compared with the 4.4% per annum forecast in the perspective analysis) it is reasonable to assume that this expansion of regional dynamism will attract new contingents of population. In fact the behavioural equation described makes it possible to determine that the rate of net migration will rise from 1.23% per annum (the rate forecast in the perspective analysis) to 2.38%. This rise should mean a population growth of 106,749 persons by 1985 and 261,258 by 1990. In 1990, therefore, the region's population should reach a total of 2,505,783 inhabitants , which implies an annual growth rate of 4.66% during the decade.

In addition to the impact on population growth, the increased employment generated in the region should lead to a reduction in underemployment and eventually to a better distribution of income and a greater equality of opportunities.

The health, sanitation and education projects, for their part, are based on the need to reduce the region's serious deficiencies in these areas. The direct effects of these projects will be a qualitative and quantitative improvement in services and a greater access to them on the part of the population, especially the lower income groups.

Owing to the fact that the proposed actions to improve and extend the scope of these services are rather limited, they do not by any means constitute a definitive solution to the region's problems. The actions in question should be viewed as a first step intended to find a short-term solution to the most urgent problems; they should be supplemented by medium and long-term sectorial plans to be implemented by the relevant departments of the state governments concerned.

8.3.3 Environmental and spatial impact

The preservation of the ecological equilibrium, the rational use of space, and reconciling the satisfaction of social needs with the productive efficiency of the suggested economic activities, constitute separate elements of the strategy proposed for regional development.

The achievement of these objectives of a general nature does not depend on specific actions or projects but on the way in which the actions or projects will be implemented and geographically distributed.

In fact, the preservation of the ecological equilibrium was regarded as a goal in the definition of the models for agriculture and cattle-raising leading to the search for more efficient ways of integrating both these activities. Since these recommendations reconcile the preservation of the productivity of the land with the maximization of the profitability of farms in the medium and long term, it is assumed that their adoption will depend only on suitable guidance being given to producers. This guidance should be given through the technical assistance programme and the norms regulating the granting of credit. In accordance with the above, the effects of these forms of exploitation on the productivity of the natural resources are significant and are manifested in the profitability of farms.

From the spatial viewpoint it is intended to reconcile the occupation of the region's land area with an increased access of the population to basic services of a satisfactory standard. For this purpose it will be necessary to strengthen the system of urban centres, improve the transport and communications systems and increase the integration of the urban centres with their respective rural peripheries.

The achievement of these objectives entails the adaptation of the regional socio-economic system to the characteristics of the land in such a way that the physical investments made at this stage shall be relevant to future needs. To this end the need arises to act upon the structural variables of the area's spatial organization. In other words, it is necessary to stimulate the creation of industries and units that perform services in the neighbourhood of the areas of greatest potential for agriculture, cattle-raising and mining, complete the road network in order to make the second and third level urban centres economically viable, ensure the supply of electric power to these nuclei, and create a physical urban infrastructure that, in addition to meeting the needs of the resident population, will generate incentives for private investment.

In this connection it is expected that the implementation of the actions and projects contained in the plan proposed by EDIBAP will contribute to modifying the spatial behaviour of the regional socio-economic system, thereby diminishing the region's present high degree of dependency vis-à-vis other states. These objectives will be achieved by means of a greater integration of the regional structure of production which, in addition to increasing the value of its exports, will also make it possible to attain a standard of competitive efficiency at the national level.

Thus, the identification of programme-areas should be viewed as the selection of sub-regional spaces capable of constituting options susceptible to productive specialization and, accordingly, of constituting territorial units suitable for the implementation of integrated programmes of development.

The projects and actions proposed for agriculture and cattle raising, besides contributing to the increase in the level of activity of these sectors in the region, should lead to a greater occupation of the potentially more productive zones. This should lead to an increased physical production that will make processing industries viable on a sub-regional scale and also to a larger market for the businesses located in the central nuclei of the respective programme-areas. Obviously, these two elements constitute a means of making the productive specializations in question materialize.

A high proportion (75%) of the projects identified should, for their part, be located in average-sized towns; only 25% of them are to be in the state capitals. This implies, among other things, creating the necessary purchasing power for primary products in the interior of the region, increasing the use of certain specialized labour in small urban nuclei, and generating conditions for the establishment of intermediary activities and personal services in cities different from the traditional urban centres. The effects of these projects are complemented by the concentration, in second and third level urban centres, of the investments in health, basic sanitation, education and urban infrastructure proposed in the plan.

Finally, the road construction and improvement programme was planned in such a way as to increase, as a matter of priority, the interaction of the urban centres with their respective rural peripheries.

From the above it may be concluded that the proposed projects and actions are part of a particular conception of spatial development that aims to create physical conditions for generating a solid, dynamic and, in the national context, competitive regional economy.

It is, however, important to point out that in spite of the coherence that the proposed strategy may have, it must be borne in mind that the creation of an efficient and stable spatial structure is a task demanding the commitment of several generations.

Consequently, the spatial dimension of the actions and projects proposed in the strategy create the basic conditions, which state and national governments must maintain, for obtaining the contribution of the regional community itself and of outside agents to the task of generating, for the region, a self-supporting process of development.

CHAPTER NINE

APPRAISAL

9. APPRAISAL

Starting from the recognition that regional planning practice in Latin America has not fulfilled the expectations it generated among planners and public authorities, the aim of this thesis is to formulate a procedural framework for this activity that will increase its flexibility and provide it with a greater capacity to deal with highly complex and adaptive systems such as regions.

In pursuing this objective some of the most noticeable shortcomings of both the procedural and the substantive frameworks of regional planning were first reviewed in broad outline.

With regard to the substantive framework the review led to the conclusion that current theories of regional development are lacking in comprehensiveness and basically comprise a number of tentative approaches to the inclusion of the variable space as a determinant element of development options open to a socioeconomic system. These theories are mostly partial, emphasizing the treatment of fundamentally economic variables or centering upon functional urbanistic approaches. As such, they are not able to answer many practical problems, although they might define some basic guidelines for the formulation of regional development policies.

From another point of view the way in which planning was introduced into public admininstration in Latin American countries, together with the indadequacy of traditional planning methodologies to deal with structurally unstable socio-economic systems, accounts for a great part of the procedural problems that this activity is currently facing. It seems that the most serious shortcomings of the procedural framework of regional planning are the lack of integration of this activity with the decision-making process and the widespread tendency towards the so-called "blue-print planning".

The joint effect of weak theories of regional development and excessively rigid procedures has naturally been responsible for the poor performance of regional planning.

Although any attempt to improve the efficacy of regional planning proposals would require the strengthening of both substantive and procedural frameworks, this thesis concentrates on the second aspect on the expectation that, if flexible procedures permitting a greater integration of planning activities with the decision-making process were available, some of the deficiencies identified could be overcome.

Thus, after analysing the requirements of decision-making, systems theory and cybernetics, a "strategy-projects" approach to regional planning was proposed as a simpler and more flexible procedural framework.

The proposed approach tries to avoid the formulation of big and detailed development plans and emphasizes the definition of strategies and the study of projects and specific actions that make the strategies operative. Starting from the recognition of the great complexity and dynamism of regional systems, the proposed procedural framework conceives planning as a tool for enhancing the rationality of the decision-making process. Therefore, planning activities are organized so as to provide a wide cover for three critical aspects of any attempt at promoting regional development which, obviously, constitute the subject matter of fundamental decisions in the planning process. These are: a) formulation of development strategies; b) identification, study and evaluation of investment projects and specific actions; and c) definition and specification of policy instruments.

Underlying this procedural framework is the "mixed - scanning" approach to decision-making which provides a flexible and selective criterion for defining the level of detail at which different studies may be carried out. In fact, since the allocation of resources for scanning at different levels is left to the decision-maker's judgment, this approach is flexible enough to be adapted to situations which may differ in terms of the decision-maker's capacity to control the system as well as the effectiveness of the initial decisions adopted. Thus, a highly incremental view is to be preferred for stable systems where previous decisions were yielding satisfactory results, and in situations where the control capacity is limited. Conversely, a more rationalistic approach is required in the opposite situation.

The proposed planning process is organized according to a cybernetic view of control of complex and adaptive systems. This leads to a distribution of functions among the various units forming part of a regional government, leaving the coordination of the whole process to the planning unit.

The main functions of such a body are the formulation of a model of the regional system that will permit the assessment of the contribution the projects and actions under consideration would make to regional development, the evaluation of the effects of any change in the region's parametric framework and also the formulation of development strategies that reconcile both the regional management capacity (measured in terms of available policy instruments) and specific projects and actions.

The central element of the proposed methodological approach is the development strategy which, after obtaining political agreement, is further specified by the planning unit. Such specification involves two aspects: on the one hand, investment projects and concrete actions are selected for meeting the requirements of the strategy; on the other, available policy instruments are made compatible with selected projects and actions, which at this stage have already been studied in full detail or negotiated with the official bodies in charge of their implementation. The specified strategy will, then, consist of a set of projects and actions to be implemented, together with the policy instruments and administrative measures required to carry them out. The strategy is later disaggregated into short-term or annual programmes of action, giving size to budgetary programming and the chronological ordering of actions.

The possibility of simulating alternative courses of action open to the regional government through a model of the socio-economic system constitutes the main feature of this conception of planning. Dynamic simulation is a quick and easy method both for studying the possible consequences that may result from choosing a particular course of action and for evaluating the impact of specific activities and projects. As such, it is of great help to regional authorities in negotiations with the central government or other agents, since it allows a rapid evaluation of the alternatives and thereby reduces the time required for decision-making.

The proposed procedural framework for regional planning was utilized as the basic methodology in the Integrated Study for the Development of the Upper Paraguay River Basin (EDIBAP). Thus, a socio-economic model of the regional system was formulated and the study of policy instruments and of investment projects and specific actions was emphasized.

By simulating the model a development strategy was obtained which was further compatibilized with investment projects and specific actions, and then harmonized with available policy instruments.

In this way an assessment of the proposed approach to regional planning entails an analysis of the model's performance and a discussion about the extent to which such a framework satisfies the requirements of effective planning. The following sections are devoted to these topics.

9.1 LIMITATIONS AND WEAKNESSES OF THE MODEL

It is generally understood that a model is an artificial conceptual construction built for the purpose of obtaining specific information about the main features of the behaviour or structure of a system. It follows that the characteristics of any model are basically defined by two factors: the characteristics of the system to be modelled, and the purposes for which the model is being built.

Thus, any assessment of the model's performance has to take into account the structural conditions of the regional system and the institutional context in which it will be utilized.

It has to be recognized, therefore, that the model does not aim at comprehensiveness but was designed to fit the requirements of the formulation of a regional development plan for a region officially defined as an expansion zone for agricultural and cattle-raising.

In fact, the Third National Development Plan and current regional development policies explicity establish that the Upper Paraguay River Basin has to contribute to national development by:

a) Providing the national market with significant quantities of food, raw materials, minerals and timber, and also by exporting products derived from agriculture and cattle-raising.

b) Acting as a receiver area of interregional migration and as an area of expansion of the agricultural frontier, and

c) Constituting the basis for the process of incorporating the Amazon Region into the Brazilian socio-economic system.

The contract of technical assistance that generated EDIBAP, for its part, establishes that the study should lead to the formulation of a comprehensive plan for the utilization of the natural resources endowment of the Upper Paraguay River Basin. Such a plan should emphasize the following aspects: development of agriculture and cattle-raising, manufacture of regional raw materials, regularization of the main courses of water, transportation, expansion of the supply of energy, ecology, human resources and urban development.

Thus, the structure of the simulation model is basically defined by the institutional and political context that gave rise to EDIBAP. In addition to these constraints, limitations of time and statistical data account for the final structure of the model.

Although the formulation of the model was greatly simplified by a strict definition of the purposes it was intended to serve, its current version is far from perfect and is to be regarded as a first attempt at representing in mathematical terms the set of cause-effect relationships that explain the development of the regional system.

In fact the model presents many weaknesses, some of which will be discussed in following pages.

From an econometric point of view the most significant li mitation of the model lies in the reduced set of observati ons utilized for its calibration and validation. Twelve observations for cross-section analysis and fifteen for time series do not constitute a wide enough sample for a sound calibration of any behavioural function.

Although this is a valid criticism, the non-existence of a better statistical background leads to the problem of to what extent the construction of a model is justified un der such conditions.

In order to answer such a difficult question two types of elements have to be considered. On the one hand, the lack of valid statistical information is in part the consequence of the "short history" of the system under study. In fact as stated in Chapter 3, by the middle sixties the region exhibited a drastic change in its socio-economic behaviour because of exogenous factors. Since these exogenous ele ments constitute a large part of the variables to be con trolled for development purposes, any attempt at formula - ting a regional development plan has to accept the fact that only a few observations are available.

Thus, as the model is only a mathematical representation of the observed pattern of behaviour of the regional system , its alternative, namely generalizations based on a few em pirical observations, present the same weaknesses as the model but do not afford its operational advantages.

On the other hand, because of the openness and complexity of the region under study it is liable to be greatly affec ted by changes in its parametric framework (e.g. new na tional policies, changes in the regional priorities for pu blic investment, etc.)

In these circumstances a behavioural function quantified on a sound basis of historical data may prove useless because adaptive systems are able to react against a structural change in their environment by generating a complex process of adjustment to the new situation that may induce a pattern of behaviour that does not constitute a direct reaction against the initial stimulus.

In this way, although the lack of a sound statistical basis for calibrating the model reduces its validity, current formalization of the model can be considered acceptable insofar as there is no better substitute and because the structural instability of the regional system may even cast serious doubts on the benefits of the greater accuracy to be expected from a model properly fitted on historical data. However, these comments suggest that the results of the model have to be regarded as conditional predictions about the probable future behaviour of the regional system and must be fully assessed before being used for decision-making purposes.

From an economic point of view the main conceptual limitation of the model concerns the partial utilization of the selected theory of regional development.

The omission of the variables affecting the demand side of a growing economy is the main source of the differences between the model and its theoretical framework.

The reasons for not explicity considering the demand side were explained in Section 3.2, and they basically concern the fact that the limiting factors for economic growth in the Upper Paraguay River Basin are clearly on the supply side and also the lack of information for quantifying an aggregate demand function.

Although these reasons justify a prior study of the supply side variables, it must be recognized that the omission of the demand side constitutes a serious limitation of the model. Moreover, because, of this omission, important variables for any regional development study have been considered in a partial way or defined as exogenous variables, e.g. interregional trade, interregional movements of capital, public expenditure and taxation, etc.

The theoretical implications of these simplifying assumptions are many. Let us briefly mention some of the most important.

First of all, the model does not take into account interregional trade and assumes that the region will have no difficulty in selling the whole of its export production to the national or international markets.

The omission of interregional trade as an explanatory variable of regional economic growth makes it impossible to check the advantages (or adequacy) of a development strategy based on import substitution. Since "export-base theory" constitutes one of the traditional ways of explaining regional economic growth, this omission compels the policy-maker to consider those aspects exogenously when defining economic policies.

Secondly, the treatment given by the model to the interregional movements of capital is static and prevents an adequate consideration of its dynamic effects. In fact, a net inflow of capital during a relatively long period of time will produce not only an increase in the regional stock of capital, but also increased opportunities for further investment.

This is so because a persistent inflow of capital tends to improve the general confidence in the regional economy which, together with effective increases in the level of activity, serves to enlarge the range of opportunities and consequently enhances the attractiveness of the regional economy for foreign as well as internal capital.

Since the model uses the net inflow of capital as an element for determining the economic feasibility of the strategies (through the savings gap concept), it only accounts for its capacity creating effects, neglecting completely its induced effects. This situation will probably affect the model's output by distorting the measure of the economic feasibility of the strategies simulated.

In spite of its theoretical relevance and the fact that a more accurate treatment of the movements of capital would strengthen the model, it does not seem advisable, for the moment, to introduce a more complex set of relationships because of the lack of data to quantify them.

Finally, the incidence of the public sector in the regional economy requires some comment. As is known, the public sector intervenes in the regional economic system by taking part of the regional income (by means of taxation) and injecting extra income in the form of both current and capital expenditure. The net effect of the public sector's action is determined by the surplus or deficit in the public budget.

The model takes into account the expenditure side of public behaviour and also its net effect in the region (*); but

(*) Current public expenditure is included in those urban economic sectors that represent the provision of basic services (education, health,etc) and in the public administration sector. Public capital expenditure is considered as inflow of capital.

omits any consideration of taxation and its redistributive consequences.

Although the treatment is quantitatively correct, there are important qualitative aspects that are neglected. Taxation, apart from its effects on the level of disposable income , constitutes an important tool for inducing the behaviour of the regional economic system and for redistributing income.

The Brazilian economy, just like any other mixed economy,is heavily influenced by the taxation system which, in spite of being centralized, is able to produce differential spatial effects by means of exemptions, subsidies and special tax concessions. As such, it has been widely used in Brazil for establishing special tributary conditions for underprivileged regions.

Because of the omission of this element from the model, the eventual consequences in the region of any special tax policy must be determined exogenously and fed into the model in the form of variations in some of the parameters and variables representing economic policies.

This is an indirect and complex way to deal with the problem. However, any attempt to establish a more direct procedure requires a detailed consideration of the demand side, because of the effects that the level and structure of taxes produce upon consumption and investment.

The limitations of the economic submodel presented so far are exclusively concerned with the omitted demand side of the regional economy. These are by no means the only limitations of this sector of the model, but they constitute perhaps, the most critical ones. The emphasis given to the discussion of the consequences of the omission of demand side variables could lead to the erroneous belief that the supply side is properly represented in the model.

In fact, by aiming at the quantification of the probable effects of the implementation of specific economic policies, this submodel does not use sectoral production functions as traditional aggregate supply studies do. Rather, it defines a sort of "sectorial response function" that measures the probable change in the sectorial production that would result from a modification in some policy instruments and market prices (agriculture, cattle-raising, civil construction), explains their behaviour as being determined by other types of variables (timber industry, diverse industries, commerce and service industries) or simply determines their level of activity as a policy objective (export industries, mining, government).

Although this particular treatment of the supply side of the regional economy is based on empirical observations, it must be further studied and improved. However, in view of the purposes of the study and the conditions under which it was carried out this version of the economic submodel seems to be acceptable as a reasonable first approach. Besides the econometric limitations of the simulation model and the shortcomings of the economic sector already reviewed, another important weakness of the model lies in the unequal treatment given to social, economic and physical aspects of the regional system. Although the model does not aim at comprehensiveness, its structure having, to a large extent, been strongly conditioned by the objectives of EDIBAP, it should be recognized that it gives a poor and marginal consideration to social and physical variables.

In fact, social development is treated as a by-product of economic growth. It is assumed that social considerations are present at all stages of policy formulation (especially in the formulation of policies regarding employment, health, education, etc) but are only introduced into the model as parameters representing policy objectives. Obviously, this kind of treatment minimizes the importance of this dimension of the process of regional development and reproduces the traditional economic bias that characterizes regional planning. However, this deficiency can be partially justified by the absence of a general theory of regional development.

Spatial variables, for their part, are considered by disaggregating the region into programme areas, defining environmental constraints on the use of natural resources for productive purposes and in the transport sector. Nevertheless, the model only gives a highly static and partial treatment of these variables. This is confirmed by the fact that the transport sector (where spatial variables are studied more deeply) is processed independently of the rest of the model and used just for fixing the priorities of road investment projects.

In concluding this assessment of the model it can be said that in spite of the limitations and weaknesses of its present version it constitutes a first step towards a systematization of a highly subjective aspect of regional planning, i.e. the formulation of development strategies. As such, it is worthy of further research in order to improve both its theoretical background and its operationality.

This effort is justified by the importance of strategy formulation in the context of regional planning, and also because the deficiencies discussed do not invalidate the principles that sustain the model.

Perhaps the main advantage of this model lies in its analytical simplicity, as well as the fact that it does not require too sophisticated data to be simulated. Since any improvement of the model is likely to be carried out at the risk of jeopardising its simplicity, the benefits of further theoretical developments must be weighed against the extra complexity they imply.

Although this is generally understood it might be useful to emphasize the potential danger implicit in trying to reach an extremely precise formulation of the model. This could lead to its output being considered as an optimum development strategy, thus transforming the model into a system which will drain out all creativity from the planning process, thereby converting it into a mechanical set of activities for the implementation of the model's output.

Nevertheless, the current version of the model can and must be perfected in order to improve its validity and efficiency, without creating any of the above-mentioned problems. There are at least two main lines along which further research is required.

Firstly, it is necessary to improve the treatment given to non-economic variables so as to allow the testing of comprehensive development strategies. As mentioned earlier, this aspect ideally requires as a starting point the integration of political, social, environmental and economic variables into a general theory of development. This is quite a remote and unachievable objective; however, existing knowledge in these fields does permit the formulation of a more rigo rous model. Thus, the validity of the model can be considerably increased by including explicit social policies as part of the strategies to be tested. This would imply a set of equations to explain the way in which social variables (that constitute a new subject for objectives formulation) are interrelated with the existing demographic, economic and environmental variables.

Another source of further improvement concerns environmental aspects. Here research is required for transforming the passive character given to ecological and physical variables into a dynamic role.

Special attention should be devoted to the consideration of the effects that the spatial distribution of economic activities and population, as well as the potentiality of natural resources, produces on the level of development.

Secondly, it can be inferred from the preceding pages that the theoretical approach to economic growth is a subject that requires further study. As the main weaknesses of the treatment given to economic variables have already been discussed, no further comments seem necessary, for overcoming those deficiencies constitutes the obvious goal of research.

9.2 POTENTIALITIES AND SHORTCOMINGS OF THE PROPOSED PROCEDURAL FRAMEWORK

The application of the proposed methodology to the Integrated Study for the Development of the Upper Paraguay River Basin provided a good opportunity for evaluating its possibilities and limitations.

The case study, however, did not allow a comprehensive assessment of the methodology because it was subject to certain constraints both of scope and of time and also because the project was carried out almost without any direct contact with the authorities in charge of promoting the development of the region. For the purposes of this thesis the lack of contact with day-to-day decision making is, perhaps, the most important limitation of the case study, since the main contribution expected of the proposed methodology is precisely to provide a framework for a closer relationship between planning activities and decision making.

Although this situation prevented an adequate assessment of the proposed procedural framework in its principal aspect, it did at least permit the study of the way in which this methodology contributed to the solution of some of the problems associated with the formulation of a regional development plan. As the proposed methodological approach aims to replace the formulation of plans with a combination of strategies and investment projects, the development plan for the study region must be seen as a particular case of a rigid conception of the implementation programme included in the methodology.

The strategy-projects approach was utilized in the second phase of EDIBAP when a socio-economic diagnosis, detailed studies of natural resources, and even an initial identification of investment projects were available. The existence of these studies greatly simplified the situation to which the methodology was to be applied but severely restricted its field of action. Perhaps the most significant constraint was that the first phase took more than three quarters of the project's total duration. Thus, the rest of the work, including some studies not carried out in the first phase such as an institutional survey, analysis of policy instruments, etc., had to be done in approximately six months. These conditions naturally meant that the methodology was utilized as a tool for integrating those basic studies into a regional development plan, but not for orientating the whole work entailed by such a commitment. As a result many limitations of the proposed procedural framework can be mentioned. However, in order to maintain the analysis at a theoretical level, only a few problems regarding the formulation of development strategies and the use of the simulation model will be reviewed here.

In the first place, the formulation of strategies proved, in practice, to be much more complex than expected. This complexity basically derives from the role the methodology assigns to the strategy in the context of the whole planning process. In fact the strategy is the element that compatibilizes goals, policy instruments, investment projects and specific actions and harmonizes them into a coherent set of interventions in the regional system. Insofar as this approach tries to avoid the formulation of a proper plan, the strategy comes to be the element that orientates the whole process and also constitutes the standard for evaluating any progress the regional system may exhibit.

Thus, in order to prevent the strategy from being rendered inoperative by minor changes in the regional system, it has to be formulated in quite general terms but, at the same time, since it must constitute an adequate guide for specific decisions, any source of ambiguity has to be eradicated.

Stated in this way, the main problem involved in the formulation of a development strategy is to determine the level of generality of its orientations that most fully satisfies both types of requirements.

Achieving such a specification of the strategy was not easy and in practice a great use of intuition was required, which made the task sometimes quite bewildering. A large part of the problems were due to the lack of accuracy of the model and also the difficulty of compatibilizing too general policies with too specific projects. This led to many reformulations of the model and partial policies and to a greater specification of the investment projects under study. Thus, a successive approximation's method was adopted that combined the model's quantitative results with qualitative judgements. Schematically this process can be presented as a set of interrelated stages. Let us examine them briefly.

Firstly, once the model was satisfactorily calibrated a series of simulations were carried out for estimating the most likely future regional situation on the assumption that historical tendencies were maintained. This proved to be quite difficult because important changes in the behaviour of independent variables were expected as a result of the new policies adopted by the Federal Government to combat inflation. Thus, a sort of prospective analysis was necessary (see Section 8.1).

Secondly, the results of the model's simulations were assessed in the light of the goals set for the study area by the Brazilian Government and were also compared with available sectorial studies. This led to an initial specification of the broadly defined regional goals and to the selection of certain courses of action.

The next step consisted of an analysis of the investment projects and specific actions being considered by the "projects-team" of EDIBAP and their harmonization with the goals of the strategy. As mentioned above, the main problem here was that the initial formulation of goals and policies was so general that it did not provide any criteria for assessing the extent to which such projects were functional to the desired objectives. This generated a sort of trial and error procedure that led to a compatibility solution by narrowing the scope of policies and by working out some general justification for the selected projects. This led to the definition of some sets of projects that comprise a group of private investment projects and actions to be implemented by public agencies, linked by technological or complementary relationships. This was taken as an intermediate element between policies and projects and greatly simplified the harmonization process.

In the fourth step the model was simulated on the assumption that all selected projects would be implemented as scheduled. This made it possible both to evaluate the extent to which the implementation of such a group of projects would lead to the achievement of the regional goals and to test the economic feasibility of the strategy.

After some study of the model's results it was concluded that the amount of productive investment entailed by selected projects was not big enough to produce any significant alteration in the forecast regional level of economic activity. Thus it was necessary to increase the number and volume of projects to be studied and also to review the targets established for agriculture and cattle-raising. This process was repeated twice before reasonable results were obtained.

It is important to note that in this respect the study confirmed, as many authors have pointed out, that one of the greatest "bottle-necks" for effective regional planning is the low capacity of backward regions (and also of public agencies) for identifying and formulating investment projects.

Although it is assumed on theoretical grounds that at a given stage of the formulation of a regional development plan a selection of the "best" projects among the various existing ones is performed, it was revealed in practice that such previously studied projects usually did not exist. Moreover, it was found that the formulation of additional projects entails requirements that are very difficult to meet. In order to solve this critical problem it seems necessary to find a way of stimulating private initiative within the context defined by flexible development policies. This, obviously, requires a greater theoretical capability and procedural efficiency on the part of planning systems.

Finally, in the fifth step existing policy instruments were studied in order to determine how they must be managed for ensuring both that the projected investment projects will materialize and that public and private agents will adopt the behaviour the strategy assumed for them. Since EDIBAP formulated these proposals independently of the regional authorities and federal authorities in charge of regional development, the analysis of these aspects led only to a set of recommendations for implementation that have to be seen as preconditions for the achievement of the proposed regional goals. Although this solution may be acceptable in the institutional context of EDIBAP, it raises the question of the effectiveness of planning proposals generated outside the policy-making level.

In fact, insofar as planning is understood as an auxiliary tool in the decision-making process, it must be carried out at the level where decisions are taken and has to be organized so as to provide the information required at that level. Although this is a perfectly obvious statement, it does at least contain some of the conditions that must be satisfied for a correct adaptation of the proposed procedural framework to a specific regional situation. The strategy-projects approach to regional planning has been defined both in terms of the type of activities involved in the formulation of effective planning proposals and in terms of a scheme for organizing such activities. Thus, its application to a particular system of regional government may entail the reorganization of the planning body and the redefinition of normal information channels.

For such a task it is important to define the "decision-making space" of regional authorities, identifying policy instruments susceptible of control at this level and the degree to which this control can be exercised. The organization of the planning system must, then, provide it with the "requisite variety" to match the complexity of policy-making activities which, in turn, is a function of the number and type of available policy instruments and of the power of regional authorities to manage them.

In addition to this condition of variety, the strategy-projects approach entails the institutionalization of planning as a permanent system of information for decision making. Thus, great care must be devoted to the definition of adequate information channels for providing an up-to-date view of the state of the regional system, including periodic evaluations of the effects of the implementation of specific projects as well as administrative actions.

To conclude this general assessment of the proposed procedural framework let us briefly examine the use of the model in this methodological context.

In spite of its limitations and weaknesses, the model proved to be a very useful tool both for providing a simplified view of the basic relationships that link the main variables of the regional system and for carrying out a partial analysis of the probable consequences that may result from specific interventions in the system.

This greatly increased the planning team's analytical capacity for exploring new courses of action and for avoiding excessive work on irrelevant aspects. In spite of these positive contributions the model has a limited field of action. In fact it can only be used when the phenomenon under study is susceptible to quantification and even then the whole problem must be defined in terms acceptable to the model's algorithm. Perhaps the greatest risk that the use of a model like this may involve is the tendency to artificially reduce the complexity of the regional system and of the problem it faces so as to adapt them to the limited capacity of the model. It is obviously necessary to prevent planners from such a "model biased" conception because it not only involves a simplistic view of regional problems but also may lead to valid courses of action being disregarded simply because they cannot be studied by means of simulations on the model.

From another point of view it is necessary to be aware that model formulation is a time consuming and quite expensive task. The allocation of resources for this purpose is clearly justified when the model is designed to complement a wider and permanent system of information for decision-making, but for sporadic studies it seems preferable to explore other, cheaper solutions.

APPENDICES

APPENDIX I

THE COMPUTER PROGRAMME

APPENDIX I

THE COMPUTER PROGRAMME

For a better understanding of the computer programme utilized for simulating the model this appendix presents a specially simplified print out of the programme.

Simplifications comprise the omission of all instructions regarding dimension of variables, reading, written and format commands, as well as the inclusion of comments explaining the function performed by each part of the programme and a glossary of the variables utilized.

The programme is composed of a relatively small monitoring section (main program) which performs the functions of the composite model including some sectors of the physical and environmental submodel. It is complemented by five subroutines that deal with specific sectors of the model. They are:

- subroutine SUBDEM, corresponding to the demographic and employment submodel.
- subroutine SUBAGR, corresponding to the agricultural sector of the economic submodel.
- subroutine SUBPEC, corresponding to the cattle raising sector of the economic submodel.
- subroutine SUBIND, corresponding to the industrial sector of the economic submodel.
- subroutine SUBSRV, corresponding to the tertiary sector of the economic submodel.

****

1. COMPOSITE MODEL
   (MAIN PROGRAM)

1.1 INSTRUCTIONS FOR CONTROLLING INTERACTIONS BETWEEN SUB-MODELS

```
DO 91 I=1,15
    CALL SUBDEM(I,1975,POPU,POPR,CREMP,PEP,FTRUR,FTURB)
    J=I+1
    CALL SUBAGR(J,1975,POPR,SEMPPT,SUPP1,VPAGR)
    CALL SUBPEC(J,1975,EMPEC,SUPP1,VPRPEC)
    CALL SUBIND(I,1975,POPU,POPR,DESMAT,EMPJ,VAPIND)
    CALL SUBSRV(I,1975,EMPUS,POPJ,VAPCSC)
    IANOP = 1975 + I
    DO 93 K=1,12
```

1.2 DETERMINATION OF INVESTMENTS REQUIRED BY HEALTH AND
    EDUCATION SECTORS

1.2.1 HEALTH SECTOR

IDENTITIES FOR DETERMINING REQUIREMENTS OF HEALTH FACILITIES

```
DEFPS(K,I) = NDISTR(K,I) - STPS(K,I-1)
DEFCS(K,I) = NMUNIC(K,I) - STCS(K,I-1)
DEFUM(A,T) = 1 - STUN(K,I-1)
STPS(K,I) = STPS(K,I-1) + POSTO(K,I)
STCS(K,I) = STCS(K,I-1) + CENTR(K,I)
STUM(K,I) = STUM(K,I-1) + UMIX(K,I)
INVSA(K,I) = POSTO(K,I)*COSPO + CENTR(K,I)*COSCE + UMIX(K,I)*COSUM
```

DEFPS(K,I) - SHORTAGE OF HEALTH POSTS, PROGR. AREA K, YEAR I
DEFCS(K,I) - SHORTAGE OF HEALTH CENTRES, PROGR. AREA K, YEAR I
DEFUM(K,I) - SHORTAGE OF MIXED UNITS, PROGR. AREA K,YEAR I
NDISTR(K,I) - NUMBER OF DISTRICTS, PROGR. AREA K, YEAR I
NMUNIC(K,I) - NUMBER OF MUNICIPALITIES, PROGR. AREA K, YEAR I
STPS(K,I-1) - EXISTING HEALTH POSTS, PROGR. AREA K, YEAR I-1
STCS(K,I-1) - EXISTING HEALTH CENTRES, PROGR. AREA K, YEAR I-1
STUM(K,I-1) - EXISTING MIXED UNITS, PROGR. AREA K, YEAR I-1
POSTO(K,I) - HEALTH POSTS TO BE BUILT, PROGR. AREA K, YEAR I
CENTR(K,I) - HEALTH CENTRES TO BE BUILT, PROGR. AREA K, YEAR I
UMIX(K,I) - MIXED UNITS TO BE BUILT, PROGR. AREA K, YEAR I
COSPO - UNIT COST, HEALTH POST
COSCE - UNIT COST, HEALTH CENTRE

```
COSUM - UNIT COST, MIXED UNIT
INVSA(K,I) - TOTAL INVESTMENT, HEALTH UNITS, PROGR. AREA K, YEAR I
```

1.2.2 EDUCATION SECTOR

IDENTITIES FOR DETERMINING REQUIREMENTS OF SCHOOLS

```
      REQESU(K,I) = 0
      REQESR(K,I) = 0
      DO 95 S=1,2
      DO 96 E=2,3
      REQESU(K,I) = REQESU(K,I) + POPU(S,E,K,I)*CESCU
      REQESR(K,I) = REQESR(K,I) + POPR(S,E,K,I)*CESCR
   96 CONTINUE
   95 CONTINUE
      DEFESU(K,I) = REQESU(K,I) - STESU(K,I-1)
      DEFESR(K,I) = REQESR(K,I) - STESR(K,I-1)
      STESU(K,I) = STESU(K,I-1) + ESCU(K,I)
      STESR(K,I) = STESR(K,I-1) + ESCR(K,I)
      INVED(K,I) = ESCU(K,I)*COSEU + ESCR(K,I)*COSER
```

```
REQESU(K,I) - NEED FOR URBAN SCHOOLS, PROGR. AREA K, YEAR I
REQESR(K,I) - NEED FOR RURAL SCHOOLS, PROGR. AREA K, YEAR I
CESCU - STANDARD OF PUPILS PER SCHOOL, URBAN ZONES
CESCR - STANDARD OF PUPILS PER SCHOOL, RURAL ZONES
DEFESU(K,I) - SHORTAGE OF URBAN SCHOOLS, PROGR. AREA K, YEAR I
DEFESR(K,I) - SHORTAGE OF RURAL SCHOOLS, PROGR. AREA K, YEAR I
STESU(K,I-1) - EXISTING URBAN SCHOOLS, PROGR. AREA K, YEAR I-1
STESR(K,I-1) - EXISTING RURAL SCHOOLS, PROGR. AREA K, YEAR I-1
ESCU(K,I) - URBAN SCHOOLS TO BE BUILT, PROGR. AREA K, YEAR I
ESCR(K,I) - RURAL SCHOOLS TO BE BUILT, PROGR. AREA K, YEAR I.
COSEU - UNIT COST, URBAN SCHOOL
COSER - UNIT COST, RURAL SCHOOL
INVED(K,I) - TOTAL INVESTMENT, SCHOOLS, PROGR. AREA K, YEAR I
```

1.3 DETERMINATION OF INDICES OF PERFORMANCE OF THE REGIONAL ECONOMY

IDENTITIES FOR DETERMINING TOTAL PRODUCT, RATE OF GROWTH OF TOTAL PRODUCT AND PRODUCT PER CAPITA FOR EACH PROGRAMME-AREA

```
      TOTPRD(K,I) = VPAGR(K,I)*0.689 + VPRPEC(K,I)*0.443 + VAPIND(K,I)
     *              + VAPCSC(K,I)
      TXCREC(K,I) = (TOTPRD(K,I)/TOTPRD(K,I-1)) - 1
      IPC(K,I) = TOTPRD(K,I)/(POPR(K,I) + POPU(K,I))*1000.
```

TOTPRO(K,I) - TOTAL PRODUCT, PROGR. AREA K, YEAR I
VPAGR(K,I) - VALUE OF AGRICULTURAL PRODUCTION, PROGR. AREA K, YEAR I
VPRPEC(K,I) - VALUE OF CATTLE RAISING PRODUCTION, PROGR. AREA K, YEAR I
VAPIND(K,I) - ADDED VALUE OF INDUSTRY, PROGR. AREA K, YEAR I
VAPCSC(K,I) - ADDED VALUE OF TERTIARY SECTOR, PROGR. AREA K, YEAR I
0.589 - ADDED VALUE / VALUE OF PRODUCTION RATIO, AGRICULTURE
0.443 - ADDED VALUE / VALUE OF PRODUCTION RATIO, CATTLE RAISING
TXCREC(K,I) - RATE OF GROWTH OF TOTAL PRODUCT, PROGR. AREA K, YEAR I
IPC(K,I) - PRODUCT PER CAPITA, PROGR. AREA K, YEAR I

IDENTITIES FOR DETERMINING TOTAL EMPLOYMENT AND UNEMPLOYMENT RATES FOR EACH PROGRAMME-AREA

```
EMPTI(K,I) = INT((SEMPPT(K,I) + EMPEC(K,I)) * CEIND(I) +
*              EMPU(K,I) + EMPUS(K,I))
CREMP(K,I) = (EMPTI(K,I)/EMPTI(K,I-1))-1
PEP(K,I) = (EMPTI(K,I) - EMPU(K,I) - EMPUS(K,I))/EMPTI(K,I)
DEMRUR(K,I) = 1. -(EMPTI(K,I) - EMPU(K,I) -EMPUS(K,I))/FTRUR(K,I)
DEMURB(K,I) = 1. -(EMPU(K,I) + EMPUS(K,I))/FTURB(K,I)
EMTOT(K,I) = 1. - EMPTI(K,I)/(FTRUR(K,I) + FTURB(K,I))
```

EMPTI(K,I) - TOTAL EMPLOYMENT, PROGR. AREA K, YEAR I
SEMPPT(K,I) - AGRICULTURAL EMPLOYMENT, PROGR. AREA K, YEAR I
CEIND(I) - TOTAL EMPLOYMENT / DIRECT EMPLOYMENT COEFFICIENT FOR THE RURAL SECTOR, YEAR I
EMPEC(K,I) - CATTLE RAISING EMPLOYMENT, PROGR. AREA K, YEAR I
EMPU(K,I) - INDUSTRIAL EMPLOYMENT, PROGR. AREA K, YEAR I
EMPUS(K,I) - TERTIARY SECTOR EMPLOYMENT, PROGR. AREA K, YEAR I
CREMP(K,I) - TOTAL EMPLOYMENT GROWTH RATE, PROGR. AREA K, YEAR I (VARIABLE TO BE USED IN THE DEMOGRAPHIC SUBMODEL)
PEP(K,I) - RURAL EMPLOYMENT/TOTAL EMPLOYMENT RATIO, PROGR. AREA K, YEAR I (VARIABLE TO BE USED IN THE DEMOGRAPHIC SUBMODEL)
DEMRUR(K,I) - RATE OF RURAL UNEMPLOYMENT, PROGR. AREA K, YEAR I
DEMURB(K,I) - RATE OF URBAN UNEMPLOYMENT, PROGR. AREA K, YEAR I
EMTOT(K,I) - RATE OF TOTAL UNEMPLOYMENT, PROGR. AREA K, YEAR I
FTRUR(K,I) - RURAL LABOUR FORCE, PROGR. AREA K, YEAR I
FTURB(K,I) - URBAN LABOUR FORCE, PROGR. AREA K, YEAR I

1.4 DETERMINATION OF THE ECONOMIC FEASIBILITY OF THE STRATEGY

IDENTITIES FOR DETERMINING NET INVESTMENT REQUIREMENTS

```
PRIINV(I) = 0
PUBINV(I) = 0
PROREG(I) = 0
```

```
    DO 97 A=1,12
    PRIINV(I) = PRIINV(I) + ((VPAGR(A,I) - VPAGR(A,I-1))*0.689*KPRAG +
   *            (VPRPEC(A,I) - VPRPEC(A,I-1))*0.443* KPRPEC +
   *            (VAMAD(A.I) - VAMAD(A,I-1))* KPRMAD +
   *            (VAMIN(A,I) - VAMIN(A,I-1))* KPRMIN +
   *            (VAIEX(A,I) - VAIEX(A,I-1))* KPRIEX +
   *            (VAIOU(A,I) - VAIOU(A,I-1))* KPRIOU +
   *            (VACON(A,I) - VACON(A,I-1))* KPRCON +
   *            (VACSE(A,I) - VACSE(A,I-1))* KPRCSE)
    PUBINV(I) = PUBINV(I) + (INVSA(A,I) + INVED(A,I) + INVTR(A,I) +
   *            (VAGOB(A,I) - VAGOB(A,I-1))* KPRGOB)

    PRIINV(I) - REGIONAL REQUIREMENTS OF PRIVATE INVESTMENT, YEAR I
    PUBINV(I) - REGIONAL REQUIREMENTS OF PUBLIC INVESTMENT, YEAR I
    KPRAG, KPRPEC,... - SECTORIAL CAPITAL/PRODUCT RATIOS
    INVTR(A,I) - TOTAL INVESTMENT IN ROADS, PROGR. AREA A, YEAR I

-----------------------------------------------------------------------

    IDENTITIES FOR DETERMINING PRIVATE SAVINGS GAP

    PROREG(I) = PROREG(I) + TOTPRD(A,I)
 97 CONTINUE
    RESAV(I) = PROREG(I)*SAVPR
    SAVGAP(I) = PRIINV(I) - RESAV(I)
 93 CONTINUE
 91 CONTINUE
    STOP
    END

    PROREG(I) - REGIONAL PRODUCT, YEAR I
    RESAV(I) - REGIONAL SAVINGS, YEAR I
    SAVPR - AVERAGE PROPENSITY TO SAVE

**********************************************************************
```

```
*****************************************************************************

2. DEMOGRAPHIC AND EMPLOYMENT SUBMODEL
   ( SUBROUTINE SUBDEM )

-----------------------------------------------------------------------------

2.1 INSTRUCTIONS FOR CONTROLLING INTERACTIONS FOR PROGRAMME-AREAS
    SEXES AND AGE COHORTS

-----------------------------------------------------------------------------

    DO 10 A=1,12
    SOMA=0
    JANO=IANO
802 IT1=0
    IT2=0
    IT3=0
    IT4=0
    IF(T.NE.1) GO TO 803
    DO 15 I=1,15
    IT1=POP(1,I,A,T)+POP(2,I,A,T)
    IT2=IT2+POP(1,I,A,T)
    IT3=IT3+POP(2,I,A,T)
    IT4=IT4+IT1
 15 CONTINUE
303 ITANO(A,1,1)=IT2
    ITANO(A,1,2)=IT3
    ITANO(A,1,3)=IT4
    IF (T.EQ.1) GO TO 700
    DO 25 I=1,15
 25 ITFE(I)=0
    ITOTM=0
    ITOTF=0
    TOTAL=0
700 DO 30 S=1,2
    DO 40 E=1,15

-----------------------------------------------------------------------------

2.2 DEMOGRAPHIC SECTOR

-----------------------------------------------------------------------------

2.2.1 DETERMINATION OF NET MIGRATION BY SEX AND AGE COHORT

-----------------------------------------------------------------------------

PROCEDURE FOR PREVENTING EXTREME VALUES OF TOTAL EMPLOYMENT
GROWTH RATES

    AVCREM(A) = (CREMP(A,T-2) + CREMP(A,T-3) + CREMP(A,T-4))/3.
    IF(CREMP(A,T-1).LT.0.7*AVCREM(A)) GOTO 20
    IF(CREMP(A,T-1).GT.1.3*AVCREM(A)) GOTO 21
 20 CREMP(A,T-1) = 0.5*AVCREM(A)
```

```
21 CREMP(A,T-1) = 1.5*AVCREM(A)


   CREMP(A,T-1) - TOTAL EMPLOYMENT GROWTH RATE, PROGR. AREA A,
                  YEAR T-1
   AVCREM(A) - AUXILIARY VARIABLE
```

```
   PROCEDURE FOR ALLOCATING BEHAVIOURAL EQUATIONS OF NET MIGRATION
   RATES TO EACH SEX AND AGE COHORT

   IF (T.EQ.1) GO TO 710
   IF((E.LE.3).AND.(S.LE.2)) GOTO 16
   IF((E.GE.4).AND.(E.LE.10).AND.(S.EQ.1)) GOTO 17
   IF((E.GE.4).AND.(E.LE.10).AND.(S.EQ.2)) GOTO 18
   IF((E.GT.10).AND.(S.EQ.1)) GOTO 19
```

```
   BEHAVIOURAL EQUATIONS OF NET MIGRATION RATES

   TMIG(S,E,A,T)=-2.7560+0.6572*CREMP(A,T-1)
   GOTO 191
16 TMIG(S,E,A,T)=-3.2241+0.9701*CREMP(A,T-1)
   GOTO 191
17 TMIG (S,E,A,T)=-1.9971+0.8826*CREMP(A,T-1)
   GOTO 191
18 TMIG(S,E,A,T)=-2.6058+0.8538*CREMP(A,T-1)
   GOTO 191
19 TMIG(S,E,A,T)=-3.0465+0.8304*CREMP(A,T-1)


   TMIG(S,E,A,T) - NET MIGRATION RATE, SEX S, AGE COHORT E, PROGR.
                   AREA A, YEAR T
```

```
   IDENTITY FOR DETERMINING NET MIGRATION BY SEX AND AGE COHORT

191 SML(S,E,A,T)=POP(S,E,A,T-1)*TMIG(S,E,A,T)/100.


   SML(S,E,A,T) - NET MIGRANTS, SEX S, AGE COHORT E, PROGR. AREA A,
                  YEAR T
   POP(S,E,A,T-1) - POPULATION, SEX S, AGE COHORT E, PROGR. AREA A,
                  YEAR T-1
```

2.2.2 DETERMINATION OF TOTAL POPULATION OF EACH SEX AND AGE COHORT

IDENTITY FOR DETERMINING THE NUMBER OF PEOPLE LEAVING EACH AGE COHORT

```
      IF(E.EQ.15) GOTO 50
      GO(S,E,A,T)=POP(S,E,A,T-1)/5
      GOTO 51
   50 GO(S,E,A,T)=0
```

GO(S,E,A,T) - PEOPLE LEAVING AGE COHORT E, SEX S, PROGR. AREA A, YEAR T

PROCEDURE FOR ALLOCATING FERTILITY RATES TO URBAN AND RURAL AREAS

```
   51 IF(.NOT.((E.EQ.1).AND.(S.EQ.1)))GOTO 48
      SOMA1=0
      DO 45 E1=4,10
      IF((A.EQ.3).OR.(A.EQ.8))XFERT=TFERT1(E1)
      IF(.NOT.((A.EQ.3).OR.(A.EQ.8)))XFERT=TFERT(E1)
```

IDENTITY FOR DETERMINING TOTAL BIRTHS FOR EACH PROGRAMME-AREA

```
   45 SOMA1=SOMA1+(POP(2,E1,A,T-1)*XFERT/1000.)
```

XFERT - FERTILITY RATE
SOMA1 - AUXILIARY VARIABLE

IDENTITY FOR DETERMINING MALE BIRTHS

```
      GI(S,E,A,T)=0.5122*SOMA1*(1-110.85/1000.)
      GOTO 61
```

GI(S,E,A,T) - PEOPLE ENTERING AGE COHORT E, SEX S, PROGR. AREA A, YEAR T
0.5122 - MASCULINITY RATE AT BIRTH
110.85/1000. - MORTALITY RATE, MALES, 0-1 YEARS OF AGE

IDENTITY FOR DETERMINING PEOPLE ENTERING COHORTS 2 TO 15

```
   48 IF((E.EQ.1).AND.(S.EQ.2)) GOTO 60
      GI(S,E,A,T)=POP(S,E-1,A,T-1)/5
      GOTO 61
```

```
IDENTITY FOR DETERMINING FEMALE BIRTHS

60 GI(S,E,A,T)=0.4878*SOMA1*(1-91.92/1000.)

   0.4878 - FEMININITY RATE AT BIRTH
   110.85/1000. - MORTALITY RATE, FEMALES, 0-1 YEARS OF AGE

------------------------------------------------------------------------

IDENTITY FOR DETERMINING TOTAL POPULATION OF EACH AGE COHORT

61 P=(FLOAT(POP(S,E,A,T-1))+GI(S,E,A,T)-SD(S,E,A,T))
  1 *(1-TMORT(E,S)/1000.)+SML(S,E,A,T)
   POP(S,E,A,T)=IFIX(P)

   TMORT(E,S) - MORTALITY RATE, AGE COHORT E, SEX S

------------------------------------------------------------------------

 2.2.3 DETERMINATION OF URBAN AND RURAL POPULATION
------------------------------------------------------------------------

   BEHAVIOURAL EQUATION FOR DETERMINING COEFFICIENT OF
   RURAL POPULATION

710 CPR(A,T)=0.576*(PEP(T-1,A)**1.12)

   CPR(A,T) - COEFFICIENT OF RURAL POPULATION, PROGR. AREA A, YEAR T
   PEP(T-1,A) - RURAL EMPLOYMENT/TOTAL EMPLOYMENT RATIO, YEAR T-1,
                PROGR. AREA A

------------------------------------------------------------------------

   PROCEDURE FOR PREVENTING EXTREME VALUES OF THE COEFFICIENT
   OF RURAL POPULATION

   IF(CPR(A,T).LT.0.99*CPR(A,T-1)) GOTO 28
   IF(CPR(A,T).GT.1.01*CPR(A,T-1)) GOTO 29
28 CPR(A,T)=0.99*CPR(A,T-1)
29 CPR(A,T)=1.01*CPR(A,T-1)

------------------------------------------------------------------------

   IDENTITIES FOR DETERMINING RURAL AND URBAN POPULATION

   POPR(S,E,A,T)=IFIX(POP(S,E,A,T)*CPR(A,T)/100.)
   POPU(S,E,A,T)=POP(S,E,A,T)-POPR(S,E,A,T)
40 CONTINUE
30 CONTINUE
```

```
POPR(S,E,A,T) - RURAL POPULATION, SEX S, AGE COHORT E, PROGR.
                AREA A, YEAR T
POPU(S,E,A,T) - URBAN POPULATION, SEX S, AGE COHORT E, PROGR.
                AREA A, YEAR T
```

2.3 EMPLOYMENT SECTOR

2.3.1 DETERMINATION OF RURAL AND URBAN LABOUR FORCE

IDENTITIES FOR DETERMINING RURAL AND URBAN LABOUR FORCE

```
720 SFTR=0.
    SFTU=0.
    TPOR=0.
    TPOU=0.
    DO 600 I=1,2
    DO 601 J=1,15
    SFTR=SFTR+(POPR(I,J,A,T)*TPR(J,I)/100.)
    SFTU=SFTU+(POPU(I,J,A,T)*TPU(J,I)/100.)
```

```
SFTR - RURAL LABOUR FORCE
SFTU - URBAN LABOUR FORCE
TPR(J,I) - RURAL PARTICIPATION RATE, AGE COHORT J, SEX I
TPU(J,I) - URBAN PARTICIPATION RATE, AGE COHORT J, SEX I
```

PROCEDURE FOR DISAGGREGATING RURAL AND URBAN LABOUR FORCE BY SEX

```
    TPOR=TPOR+POPR(I,J,A,T)
    TPOU=TPOU+POPU(I,J,A,T)
601 CONTINUE
    IF(I.NE.1)GOTO 602
    SFTRH=SFTR
    SFTUH=SFTU
    TPORH=TPOR
    TPOUH=TPOU
602 IF(I.NE.2) GOTO 600
    SFTRM=SFTR-SFTRH
    SFTUM=SFTU-SFTUH
    TPORM=TPOR-TPORH
    TPOUM=TPOU-TPOUH
600 CONTINUE
    FTR(A,T)=SFTR
    FTRUR(A)=SFTR
    FTU(A,T)=SFTU
    FTURB(A)=SFTU
    FTRH(A,T)=SFTRH
    FTRM(A,T)=SFTRM
```

```
FTUH(A,T)=SFTUH
FTUM(A,T)=SFTUM


FTRH(A,T) - RURAL MALE LABOUR FORCE, PROGR. AREA A, YEAR T
FTRM(A,T) - RURAL FEMALE LABOUR FORCE, PROGR. AREA A, YEAR T
FTUH(A,T) - URBAN MALE LABOUR FORCE, PROGR. AREA A, YEAR T
FTUM(A,T) - URBAN FEMALE LABOUR FORCE, PROGR. AREA A, YEAR T
TPOR, TPOU, SFTRH, SFTUH, TPORH, TPOUH, SFTRM, SFTUM, TPORM,
TPOUM, FRT(A,T), FTRUR(A), FTU(A,T),FTURB(A) - AUXILIARY VARIABLE

-----------------------------------------------------------------

IDENTITY FOR DETERMINING TOTAL LABOUR FORCE

FTRT(A,T)=FTR(A,T)+FTU(A,T)

FTRT(A,T) - TOTAL LABOUR FORCE, PROGR. AREA A, YEAR T


-----------------------------------------------------------------

2.3.2 DETERMINATION OF REQUIREMENTS OF JOBS
-----------------------------------------------------------------

IDENTITIES FOR DETERMINING MAXIMUM ACCEPTABLE UNEMPLOYMENT RATES

TDEST(T)=TDESA(T)+TSUBE(T)
TDESR(T)=TDESAR(T)+TSUBER(T)


TDEST(T) - TOTAL UNEMPLOYMENT RATE, YEAR T
TDESA(T) - RATE OF OPEN UNEMPLOYMENT, YEAR T
TSUBE(T) - RATE OF UNDER-EMPLOYMENT, YEAR T
TDESR(T) - RURAL UNEMPLOYMENT RATE, YEAR T
TDESAR(T) - RURAL OPEN UNEMPLOYMENT RATE, YEAR T
TSUBER(T) - RURAL UNDER-EMPLOYMENT RATE, YEAR T

-----------------------------------------------------------------

IDENTITIES FOR DETERMINING REQUIREMENTS OF JOBS

REMPT(A,T)=FTRT(A,T)*(1-TDEST(T))
REMPR(A,T)=FTR(A,T)*(1-TDESR(T))
REMPU(A,T)=REMPT(A,T)-REMPR(A,T)
IF (T.EQ.1)GO TO 10
10 CONTINUE
RETURN
END


REMPT(A,T) - TOTAL REQUIREMENTS OF JOBS, PROGR. AREA A, YEAR T
REMPR(A,T) - REQUIREMENTS OF RURAL JOBS, PROGR. AREA A, YEAR T
REMPU(A,T) - REQUIREMENTS OF URBAN JOBS, PROGR. AREA A, YEAR T
*****************************************************************
```

```
*****************************************************************************

  3. ECONOMIC SUBMODEL. AGRICULTURAL SECTOR
     ( SUBROUTINE SUBAGR )
-----------------------------------------------------------------------------

  3.1 DETERMINATION OF AREA DEVOTED TO CROPS AND PASTURES
-----------------------------------------------------------------------------

  BEHAVIOURAL EQUATION FOR DETERMINING THE
  REGIONAL AREA DEVOTED TO CROPS AND PASTURES

  SAPT(N)=-4991159.+603.95*REDV(N)+65.65*CRAP(N)


  SAPT(N) - LAND DEVOTED TO CROPS AND PASTURES, YEAR N
  REDV(N) - ROAD NETWORK, YEAR N
  CRAP(N) - CREDITS GRANTED FOR AGRICULTURE AND CATTLE RAISING,
            YEAR N

-----------------------------------------------------------------------------

  PROCEDURE FOR CHECKING THE ATTAINMENT OF THE ECOLOGICAL
  CONSTRAINT ON LAND DEVOTED TO CROPS AT THE REGIONAL LEVEL

  IF(SAPT(N)-BOUT)1,1,2
2 SAPT(N)=BOUT

  BOUT - REGIONAL ECOLOGICAL LIMIT FOR CROPS

-----------------------------------------------------------------------------

  PROCEDURE FOR DISAGGREGATING LAND DEVOTED TO CROPS AND PASTURES
  AT THE PROGRAMME-AREA LEVEL

1 SUM1(N)=0.
  SUM2(N)=0
  DO 300 K=1,12
  SAPP(K,N)=SAPT(N)*CDIST(K)


  SAPP(K) - LAND DEVOTED TO CROPS AND PASTURES, PROGR. AREA K,
  CDIST(K)   - COEFFICIENT FOR SPATIAL DISAGGREGATION OF SAPT
  SUM1(N), SUM2(N)- AUXILIARY VARIABLES

-----------------------------------------------------------------------------

  PROCEDURE FOR CHECKING THE ATTAINMENT OF THE ECOLOGICAL CONSTRAINT
  ON LAND DEVOTED TO CROPS AND PASTURES AT THE PROGRAMME-AREA LEVEL

  IF(SAPP(K,N)-BOU(K))3,3,4
4 SAPP(K,N)=BOU(K)
  SUM1(N)=SUM1(N)+SAPP(K,N)
  GO TO 300
```

```
  3 SUM2(N)=SUM2(N)+SAPP(K,N)
300 CONTINUE
    SUM3(N)=SUM1(N)+SUM2(N)
    DIF1(N)=SAPT(N)-SUM3(N)
    SNAPP(N)=SAPT(N)-SUM1(N)
    DO 400 L=1,12
    IF(SAPP(L,N)-BOU(L))5,6,6
  6 SAPP(L,N)=SAPP(L,N)
    GO TO 400
  5 SAPP(L,N)=SAPP(L,N)*(1+DIF1(N)/SNAPP(N))
400 CONTINUE
```

BOU(K) - ECOLOGICAL LIMIT FOR CROPS, PROGR. AREA K
SUM3(N), DIF1(N), SNAPP(N) - AUXILIARY VARIABLES

3.2 DETERMINATION OF LAND DEVOTED TO EACH CROP

AUXILIARY PROCEDURE FOR DISAGGREGATING LAND DEVOTED TO RICE AND SOYA AT THE PROGRAMME-AREA LEVEL

```
    HHA(1,N)=-12772+HHA(1,N-1)*.47+PREC1(N-1)*60.39+CRAG(N)*.44
    HHA(2,N)=-13605+HHA(2,N-1)*.46+PREC1(N-1)*72.15+CRAG(N)*.47
    HHA(3,N)=-20697+HHA(3,N-1)*.49+PREC1(N-1)*75.96+CRAG(N)*.71
    HHA(4,N)=-14769+HHA(4,N-1)*.37+PREC1(N-1)*133.43+CRAG(N)*.76
    HHA(5,N)=-18420+HHA(5,N-1)*.53+PREC1(N-1)*65.06+CRAG(N)*.67
    HHA(6,N)=-13667+HHA(6,N-1)*1.12+PREC1(N-1)*36.07+CRAG(N)*.00
    HHA(7,N)=-41349+HHA(7,N-1)*.50+PREC1(N-1)*157.86+CRAG(N)*1.52
    HHA(8,N)=-67594+HHA(8,N-1)*.51+PREC1(N-1)*241.60+CRAG(N)*3.41
    HHA(9,N)=-14269+HHA(9,N-1)*.53+PREC1(N-1)*44.70+CRAG(N)*1.30
    HHA(10,N)=-445.+HHA(10,N-1)*.41+PREC1(N-1)*3.53+CRAG(N)*.01
    HHA(11,N)=-34803.+HHA(11,N-1)*.49+PREC1(N-1)*133.38+CRAG(N)*1.34
    HHA(12,N)=-179507.+HHA(12,N-1)*1.20+PREC1(N-1)*484.39+CRAG(N)*.00
    DO 450 J=1,12
    IF(HHA(J,N)-1000.)451,450,450
451 HHA(J,N)=1000.
450 CONTINUE
    DO 605 K=1,12
```

HHA(I,N) - LAND DEVOTED TO RICE AND SOYA, PROGR. AREA I, YEAR N (AUXILIARY VARIABLE)
PREC1(N-1) - PRICE OF RICE, YEAR N-1
CRAG(N) - CREDITS GRANTED TO AGRICULTURE, YEAR N

BEHAVIOURAL EQUATION FOR DETERMINING LAND DEVOTED TO OTHER CROPS IN EACH PROGRAMME-AREA

```
    HAO(K,N)=8395.+.4067*POPR(K,N-1)
```

HAO(K,N) - LAND DEVOTED TO OTHER CROPS, PROGR. AREA K, YEAR N
POPR(K,N-1) - RURAL POPULATION, PROGR. AREA K, YEAR N-1

LAND DEVOTED TO COFFEE AND SUGAR CANE PLANTATIONS

```
HAF(K,N)=HHF(K,N)
HAC(K,N)=HHC(K,N)
```

HAF(K,N) - LAND DEVOTED TO COFFEE PLANTATIONS, PROGR. AREA A, YEAR N
HAC(K,N) - LAND DEVOTED TO SUGAR CANE PLANTATIONS, PROGR. AREA A, YEAR N

COMPLEMENT OF THE AUXILIARY PROCEDURE FOR DISAGGREGATING LAND DEVOTED TO RICE AND SOYA AT THE PROGRAMME-AREA LEVEL

```
    DIF4(K,N)=BOUND(K)-HAO(K,N)-HAF(K,N)-HAC(K,N)
    IF(HHA(K,N)-DIF4(K,N))605,605,452
452 HHA(K,N)=DIF4(K,N)
605 CONTINUE
    HHAA(N)=HHA(1,N)+HHA(2,N)+HHA(3,N)+HHA(4,N)+HHA(5,N)+HHA(6,N)+HHA(
   *7,N)+HHA(8,N)+HHA(9,N)+HHA(10,N)+HHA(11,N)+HHA(12,N)
```

BOUND(K) - ECOLOGICAL LIMIT FOR CROPS, PROGR. AREA K
DIF4(K,N), HHAA(N) - AUXILIARY VARIABLE

BEHAVIOURAL EQUATION FOR DETERMINING LAND DEVOTED TO RICE AND SOYA AT THE REGIONAL LEVEL

```
    HA(N)=-454489.0.988*HA(N-1)-0.536*HA(N-2)+1465.7*PREC1(N-1)+
   *113.8*PREC1(N-2)+12.73*CRAG(N)+9.3*CRAG(N-1)
```

HA(N) - LAND DEVOTED TO RICE AND SOYA, YEAR N.

PROCEDURE FOR DISAGGREGATING LAND DEVOTED TO RICE AND SOYA AT THE PROGRAMME-AREA LEVEL

```
    DO 606 K=1,12
    PHHA(K,N)=HHA(K,N)/HHAA(N)
    HAA(K,N)=PHHA(K,N)*HA(N)
```

HAA(K,N) - LAND DEVOTED TO RICE AND SOYA, PROGR. AREA K, YEAR N
PHHA(K,N) - AUXILIARY VARIABLE

IDENTITY FOR DETERMINING TOTAL LAND DEVOTED TO CROPS IN EACH PROGRAMME-AREA

```
    HAT(K,N)=HAA(K,N)+HAO(K,N)+HAF(K,N)+HAC(K,N)
606 CONTINUE
```

HAT(K,N) - LAND DEVOTED TO CROPS, PROGR. AREA K, YEAR N

PROCEDURE FOR CHECKING THE ATTAINMENT OF THE ECOLOGICAL CONSTRAINT FOR AGRICULTURAL LAND IN EACH PROGRAMME-AREA

```
    DO 613 I=1,12
    IF(HAT(I,N)-BOUND(I))613,613,612
613 CONTINUE
    GO TO 615
612 DO 600 I=1,12
    HAT(I,N)=HAA(I,N)+HAO(I,N)+HAF(I,N)+HAC(I,N)
    IF(HAT(I,N)-BOUND(I))600,600,11
 11 HAN(I,N)=BOUND(I)-HAF(I,N)-HAC(I,N)
    HAM(I,N)=HAT(I,N)-HAF(I,N)-HAC(I,N)
    HAA(I,N)=HAA(I,N)*HAN(I,N)/HAM(I,N)
    HAO(I,N)=HAO(I,N)*HAN(I,N)/HAM(I,N)
    HAT(I,N)=HAA(I,N)+HAO(I,N)+HAF(I,N)+HAC(I,N)
600 CONTINUE
615 DO 200 I=1,12
```

HAN(I,N), HAM(I,N) - AUXILIARY VARIABLES

IDENTITY FOR DETERMINING AREA DEVOTED TO PASTURES IN EACH PROGRAMME-AREA

```
    SPP(I,N)=SAPP(I,N)-HAT(I,N)
```

SPP(I,N) - LAND DEVOTED TO PASTURES, PROGR. AREA I, YEAR N (VARIABLE TO BE USED IN THE CATTLE RAISING SECTOR)
SAPP(I,N) - LAND DEVOTED TO CROPS AND PASTURES, PROGR. AREA I, YEAR N

IDENTITY FOR DETERMINING THE AMOUNT OF DEFORESTED LAND IN EACH PROGRAMME-AREA

```
      DESMAT(I,N)=SAPP(I,N)-SAPP(I,N-1)

      DESMAT(I,N) - DEFORESTED AREA, PROGR. AREA I, YEAR N (VARIABLE
                    TO BE USED IN THE INDUSTRIAL SECTOR)
```

3.3 DETERMINATION OF AGRICULTURAL EMLOYMENT

```
      PROCEDURE FOR SELECTING APPROPRIATE TECHNOLOGY FOR RICE AND
      SOYA CROPS

      IF(TRAC(I,N)-.20)13,13,14
   13 A=1.
      GO TO 19
   14 IF(TRAC(I,N)-.50)15,15,16
   15 A=.8
      GO TO 19
   16 IF(TRAC(I,N)-.80)17,17,18
   17 A=.50
      GO TO 19
   18 A=.2
   19 DO 500 M=1,12

      TRAC(I,N) - TRACTORS PER HECTARE COEFFICIENT, PROGR. AREA I,
                  YEAR N
```

```
      IDENTITIES FOR DETERMINING MONTHLY EMPLOYMENT GENERATED BY
      EACH CROP

      EMPAG1(I,M,N)=HAA(I,N)*(A*RMO1A(M)+(1-A)*RMO1B(M))
      EMPAG2(I,M,N)=HAO(I,N)*RMO2(M)
      EMPAG3(I,M,N)=HAF(I,N)*RMO3(M)
      EMPAG4(I,M,N)=HAC(I,N)*RMO4(M)


      EMPAG1(I,M,N) - MONTHLY EMPLOYMENT, RICE AND SOYA
      EMPAG2(I,M,N) - MONTHLY EMPLOYMENT, OTHER CROPS
      EMPAG3(I,M,N) - MONTHLY EMPLOYMENT, COFFEE
      EMPAG4(I,M,N) - MONTHLY EMPLOYMENT, SUGAR CANE
      RMO1A(M) - MONTHLY REQUIREMENT OF LABOUR, RICE AND SOYA, MANUAL
      RMO1B(M) - MONTHLY REQUIREMENT OF LABOUR, RICE AND SOYA, MECHANIC
      RMO2(M) - MONTHLY REQUIREMENT OF LABOUR, OTHER CROPS
      RMO3(M) - MONTHLY REQUIREMENT OF LABOUR, COFFEE
      RMO4(M) - MONTHLY REQUIREMENT OF LABOUR, SUGAR CANE
      A - COEFFICIENT FOR COMBINING MANUAL AND MECHANIZED TECHNOLOGIES
```

```
      PROCEDURE FOR DETERMINING PERMANENT AND TEMPORARY EMPLOYMENT
```

```
GENERATED BY AGRICULTURE IN EACH PROGRAMME-AREA

    EMPA(I,M,N)=(EMPAG1(I,M,N)+EMPAG2(I,M,N)+EMPAG3(I,M,N)+EMPAG4(I,M,
   *N))/22.
    ESINT(I,M,N)=EMPA(I,M,N)
500 CONTINUE
 23 CHAVE=0
    DO 700 M=1,11
    IF(EMPA(I,M,N)-EMPA(I,M+1,N))700,700,21
 21 T=EMPA(I,M,N)
    EMPA(I,M,N)=EMPA(I,M+1,N)
    EMPA(I,M+1,N)=T
    CHAVE=1
700 CONTINUE
    IF(CHAVE-.0)23,24,23
 24 EMPAP(I,N)=(EMPA(I,6,N)+EMPA(I,7,N))/2.
    SEMPA(I,N)=0
    DO 800 M=7,12
    EMPAT(I,N)=EMPA(I,M,N)-EMPAP(I,N)
    SEMPA(I,N)=SEMPA(I,N)+EMPAT(I,N)
800 CONTINUE
    SEMPAT(I,N)=SEMPA(I,N)/12.
```

EMPAP(I,N) - PERMANENT AGRICULTURAL EMLOYMENT, PROGR. AREA I, YEAR N

SEMPAT(I,N) - TEMPORARY AGRICULTURAL EMPLOYMENT, PROGR. AREA I, YEAR N

ESINT(I,M,N), CHAVE, EMPA(I,M,N), SEMPA(I,N), EMPAT(I,N) - AUXILIARY VARIABLES

3.4 DETERMINATION OF AGRICULTURAL PRODUCTION

IDENTITIES FOR DETERMINING AGRICULTURAL PRODUCTION

```
    PREAG1(I,N)=HAA(I,N)*PL01(N)/1000.
    VBPAG1(I,N)=PREAG1(I,N)*0.00905
    PREAG2(I,N)=HAO(I,N)*PL02(N)/1000.
    VBPAG2(I,N)=PREAG2(I,N)*0.01634
    PREAG3(I,N)=HAF(I,N)*PL03(N)/1000.
    VBPAG3(I,N)=PREAG3(I,N)*0.1239
    PREAG4(I,N)=HAC(I,N)*PL04(N)/1000.
    VBPAG4(I,N)=PREAG4(I,N)*0.00061
    VPAGR(I,N)=VBPAG1(I,N)+VBPAG2(I,N)+VBPAG3(I,N)+VBPAG4(I,N)
200 CONTINUE
    RETURN
    END
```

PREAG(C)(I,N) - PHYSICAL PRODUCTION, CROP C, PROGR. AREA I, YEAR N

VBPAG(C)(I,N) - VALUE OF PRODUCTION, CROP C, PROGR. AREA I, YEAR N

VPAGR(I,N) - VALUE OF AGRICULTURAL PRODUCTION, PROGR. AREA I,

```
        YEAR N
PLC(C)(N) - PHYSICAL PRODUCTIVITY OF LAND, CROP C, YEAR N
NUMERICAL COEFFICIENTS IN VRPAG(C)(I,N) IDENTITIES REPRESENT
MARKET PRICES OF EACH PRODUCT

****************************************************************************
```

****

4. ECONOMIC SUBMODEL. CATTLE RAISING SECTOR
(SUBROUTINE SUBPEC)

4.1 DETERMINATION OF THE EVOLUTION OF THE CATTLE STOCK

IDENTITY FOR DETERMINING THE CATTLE/PASTURES RATIO

```
    IF(T.LE.2) GO TO 402
    DO 401 K=1,12
    ANPP(K,T)=TGADO(K,T-1)/SPP1(K,T-1)
    IF(ANPP(K,T).GT.3.5) ANPP(K,T)=3.5
401 CONTINUE
    ANPP(10,T)=1.8
```

ANPP(K, T) - CATTLE/PASTURES RATIO, PROGR. AREA K, YEAR T
TGADO(K,T-1) - STOCK OF CATTLE, PROGR. AREA K, YEAR T-1
SPP(K,T-1) - LAND DEVOTED TO PASTURES, PROGR. AREA K, YEAR T-1
ECOLOGICAL CONSTRAINT. ANPP(K) CAN NOT EXCEED THE VALUE 3.5
ANPP(10), CORRESPONDING TO THE PROGRAMME-AREA OF CORUMBA WAS FIXE
EXOGENOUSLY

IDENTITIES FOR DETERMINING CATTLE STOCK UNDER 1 YEAR OF AGE

```
402 DO 5 A=1,12
    DO 10 T=2,15
    GADO(1,1,A,T)=IFIX(GADO(3,2,A,T-1)*0.45*0.50*TSOB(1,1))
    GADO(1,2,A,T)=IFIX(GADO(3,2,A,T-1)*0.45*0.50*TSOB(1,2))
```

GADO(E,S,A,T) - CATTLE, AGE COHORT E, SEX S, PROGR. AREA A, YEAR
TSOB(E,S) - SURVIVAL RATE, AGE COHORT E, SEX S
0.45 - NATALITY RATE
0.50 - SEX COEFFICIENT

BEHAVIOURAL EQUATION FOR DETERMINING TRANSFER COEFFICIENT
BETWEEN PROGRAMME-AREAS

```
TRANSF(A,T)=1.0604/(ANPP(A,T)**0.1211)
```

TRANSF(A,T) - COEFFICIENT OF CATTLE TRANSFERS, PROGR. AREA A,
YEAR T

IDENTITIES FOR DETERMINING CATTLE STOCK BETWEEN 1 AND 2

```
      YEARS OF AGE

  250 GADO(2,1,A,T)=IFIX(GADO(1,1,A,T-1)*TSOB(2,1)*TRANSF(A,T))
      GADO(2,2,A,T)=IFIX(GADO(1,2,A,T-1)*TSOB(2,2)*TRANSF(A,T))
```

```
      BEHAVIOURAL EQUATIONS FOR DETERMINING RATES OF EXTRACTION

      K=T+3
      L=T+2
      PEXT(K,1)=37.23-0.4239*PEXT(K-1,1)-0.2350*PEXT(K-2,1)-0.3926*
     1 PEXT(K-3,1)-0.66*PREC(L-1)-0.003*PREC(L-2)+0.006*CRPE(L-1)+
     1 0.0047*PREC (L-2)
      PEXT(K,2)=11.722+0.7032*PEXT(K-1,2)-0.5935*PEXT(K-2,2)+0.12003*
     1 PEXT(K-3,2)-0.0177*PREC(L-1)+0.0044*PREC(L-2)+0.0018*CRCP(L-1)-
     1 0.0005*CRCP(L-2)


      PEXT(K,S) - RATE OF EXTRACTION, CATTLE SEX S, YEAR K
      PREC(L-1) - PRICE OF MEAT, YEAR L-1
      CRPE(L-1) - TOTAL CREDITS GRANTED TO CATTLE RAISING, YEAR L-1
      CRCP(L-1) - CREDITS GRANTED TO CATTLE RAISING FOR NORMAL
                  EXPENSES, YEAR L-1
```

```
      IDENTITIES FOR DETERMINING THE NUMBER OF ANIMALS OVER 2 YEARS
      OF AGE EXTRACTED FOR SLAUGHTER EACH YEAR

      EXT(3,1,A,T)=GADO(3,1,A,T-1)*PEXT(K,1)/100.
      EXT(3,2,A,T)=GADO(3,2,A,T-1)*PEXT(K,2)/100.


      EXT(E,S,A,T) - NUMBER OF ANIMALS EXTRACTED, AGE COHORT E, SEX S
                     PROGR. AREA A, YEAR T
```

```
      IDENTITIES FOR DETERMINING CATTLE STOCK OVER 2 YEARS OF AGE

      GADO(3,1,A,T)=IFIX((GADO(3,1,A,T-1)+GADO(2,1,A,T-1)-
     1     EXT(3,1,A,T))*TSOB(3,1)*TRANSF(A,T))
      GADO(3,2,A,T)=IFIX((GADO(3,2,A,T-1)+GADO(2,2,A,T-1)-
     1     EXT(3,2,A,T))*TSOB(3,2)*TRANSF(A,T))
```

```
      PROCEDURE FOR CHECKING THE ATTAINMENT OF THE ECOLOGICAL CONSTRAINT
      ON CATTLE RAISING AT THE PROGRAMME-AREA LEVEL

      SOMA=0
      DO 20 FE=1,3
      DO 30 S=1,2
      SOMA=SOMA+GADO(FE,S,A,T)
```

```
 30 CONTINUE
 20 CONTINUE
    TGADO(A,T)=SOMA
    IF (TGADO(A,T).LE.GANPOT(A)) GO TO 300
    NGADO(A,T)=TGADO(A,T)-GANPOT(A)
    C =NGADO(A,T)
    C1=TGADO(A,T)
    G1=GADO(1,1,A,T)
    G2=GADO(1,2,A,T)
    DIFGA(A,T)=C/(C1-G1-G2)
    TRANSF(A,T)=TRANSF(A,T)*(1.-DIFGA(A,T))
    GO TO 250
```

GANPOT(A) - POTENTIAL CATTLE STOCK, PROGR. AREA A (ECOLOGICAL CONSTRAINT)
SOMA, TGADO(A,T), NGADO(A,T), DIFGA(A,T), C, C1, G1, G2 - AUXILIARY VARIABLES

4.2 DETERMINATION OF EMPLOYMENT AND PRODUCT GENERATED BY CATTLE RAISING

IDENTITY FOR DETERMINING TOTAL EMPLOYMENT

```
300 EMPEC(A,T)=IFIX(TGADO(AP,T)*0.004)
```

EMPEC(A,T) - TOTAL EMPLOYMENT IN CATTLE RAISING, PROGR. AREA A, YEAR T
0.004 - LABOUR REQUIREMENT PER UNIT OF CATTLE

IDENTITIES FOR DETERMINING THE VALUE OF PRODUCTION

```
    SOMA1=0
    DO 40 E=1,3
    DO 50 S=1,2
    SOMA1=SOMA1+(GADO(E,S,A,T)-GADO(E,S,A,T-1))*PM(E,S)*0.000984
 50 CONTINUE
 40 CONTINUE
    SOMA2=0
    DO 55 S=1,2
 55 SOMA2=SOMA2+(EXT(3,S,A,T)*PM(3,S))*0.000984
    SOMA3=( GADO(2,1,A,T)*(TRANSF(A,T) - 1.)* PM(2,1) +
   *        GADO(2,2,A,T)*(TRANSF(A,T) - 1.)*PM(2,2) +
   *        GADO(3,1,A,T)*(TRANSF(A,T) - 1.)*PM(3,1) +
   *        GADO(3,2,A,T)*(TRANSF(A,T) - 1.)*PM(3,2) )
    VPRPEC(A,T)=SOMA1+SOMA2-(SOMA3*0.000984)
 10 CONTINUE
    RETURN
```

```
END

SOMA1 - VALUE OF PRODUCTION ATTRIBUTABLE TO CATTLE STOCK GROWTH
SOMA2 - VALUE OF PRODUCTION ATTRIBUTABLE TO EXTRACTION FOR
        SLAUGHTER
SOMA3 - VALUE OF PRODUCTION ATTRIBUTABLE TO TRANSFERS BETWEEN
        PROGRAMME-AREAS
PM(E,S) - AVERAGE WEIGHT OF CATTLE, AGE COHORT E, SEX S
0.000004 - PRICE OF MEAT (IN MILLIONS CRUZEIROS)
VPRPEC(A,T) - VALUE OF PRODUCTION OF CATTLE RAISING, PROGR. AREA A
              YEAR T

****************************************************************************
```

****

5. ECONOMIC SUBMODEL. INDUSTRIAL SECTOR
(SUBROUTINE SUBIND)

5.1 BEHAVIOURAL EQUATIONS FOR DETERMINING THE LEVEL OF ACTIVITY OF EACH INDUSTRIAL BRANCH

```
DO 9 A = 1,12
VAMAD(A,N) = -56.489 + 10.14*DESMAT(A,N)/1000.
VAMIN(A,N) = VAMIN(A,N-1)*(1. + METMIN(A,N))
VAIEX(A,N) = VAIEX(A,N-1)*(1. + METIEX(A,N))
EMIOU(A,N) = INT((0.0082)*(POPU(A,N-1)**1.045))
```

```
VAMAD(A,N) - ADDED VALUE TIMBER INDUSTRIES, PROGR. AREA A, YEAR N
VAMIN(A,N) - ADDED VALUE MINING, PROGR. AREA A, YEAR N
VAIEX(A,N) - ADDED VALUE EXPORT INDUSTRIES, PROGR. AREA A, YEAR N
EMIOU(A,N) - EMPLOYMENT IN DIVERSE INDUSTRIES, PROGR. AREA A,
             YEAR N
DESMAT(A,N) - DEFORESTED AREA, PROGR. AREA A, YEAR N
METMIN(A,N) - RATE OF GROWTH MINING INDUSTRIES, PROGR. AREA A,
             YEAR N
METIEX(A,N) - RATE OF GROWTH EXPORT INDUSTRIES, PROGR. AREA A,
             YEAR N
POPU(A,N-1) - URBAN POPULATION, PROGR. AREA A, YEAR N-1
```

5.2 CONSTRAINT ON THE LEVEL OF ACTIVITY OF TIMBER INDUSTRIES

```
TESTE = (POPU(A,N) + POPR(A,N))*2.92/10000.
IF(VAMAD(A,N).LT.TESTE) VAMAD(A,N) = TESTE
```

```
2.92/10000 - NATIONAL PRODUCT PER CAPITA, TIMBER INDUSTRY (1975)
TESTE - AUXILIARY VARIABLE
```

5.3 IDENTITIES

```
  ENIMA(A,N) = INT(VAMAD(A,N)*REGMO(1,N))
  EMIMI(A,N) = INT(VAMIN(A,N)*REGMO(2,N))
  EMIEX(A,N) = INT(VAIEX(A,N)*REGMO(3,N))
  VAIOU(A,N) = EMIOU(A,N)/REGMO(4,N)
  VAPINO(A,N) = VAMAD(A,N) + VAMIN(A,N) + VAIEX(A,N) + VAIOU(A,N)
  EMPUS(A,N) = ENIMA(A,N) + EMIMI(A,N) + EMIEX(A,N) + EMIOU(A,N)
9 CONTINUE
```

```
RETURN
END

ENIMA(A,N) - EMPLOYMENT TIMBER INDUSTRIES, PROGR. AREA A, YEAR N
EMIMI(A,N) - EMPLOYMENT MINING INDUSTRIES, PROGR. AREA A, YEAR N
EMIEX(A,N) - EMPLOYMENT EXPORT INDUSTRIES, PROGR. AREA A, YEAR N
VAIDU(A,N) - ADDED VALUE DIVERSE INDUSTRIES, PROGR. AREA A, YEAR
VAPIND(A,N) - INDUSTRIAL ADDED VALUE, PROGR. AREA A, YEAR N
EMPUS(A,N) - INDUSTRIAL EMPLOYMENT, PROGR. AREA A, YEAR N
REQMO(I,N) - LABOUR REQUIREMENTS PER UNIT OF PRODUCT, INDUSTRY I,
             YEAR N

**********************************************************************
```

****

6. ECONOMIC SUBMODEL. TERTIARY SECTOR
(SUBROUTINE SUBSRV)

6.1 BEHAVIOURAL EQUATIONS FOR DETERMINING THE LEVEL OF ACTIVITY OF EACH BRANCH OF THE TERTIARY SECTOR

```
DO 8 A = 1,12
VACON(A,N) = CODI1(A)*(3229.1 + 0.5456*IHARO(N))
EMCSE(A,N) = INT(-326. + 0.1355*POPU(A,N-1))
VAGOB(A,N) = CODI2(A)*(7.78*(GCEST(N)**0.823))
```

```
VACON(A,N) - ADDED VALUE CIVIL CONSTRUCTION, PROGR. AREA A, YEAR N
EMCSE(A,N) - EMPLOYMENT COMMERCE AND SERVICES, PROGR. AREA A,
             YEAR N
VAGOB(A,N) - ADDED VALUE GOVERNMENT, PROGR. AREA A, YEAR N
IHARO(N) - CREDITS GRANTED FOR HOUSING AND PUBLIC INVESTMENT
           IN ROADS, YEAR N
GCEST(N) - CURRENT EXPENDITURE STATE GOVERNMENTS, YEAR N
CODI1(A) - COEFFICIENT FOR SPATIAL DISTRIBUTION OF ADDED VALUE
           OF CIVIL CONSTRUCTION
CODI2(A) - COEFFICIENT FOR SPATIAL DISTRIBUTION OF ADDED VALUE
           OF GOVERNMENT
```

6.2 IDENTITIES

```
  EMCON(A,N) = INT(VACON(A,N)*RMOCO(N))
  VACSE(A,N) = EMCSE(A,N)/RMOSE(N)
  EMGOB(A,N) = VAGOB(A,N)*RMOGO(N)
  VAPCSC(A,N) = VACON(A,N) + VACSE(A,N) + VAGOB(A,N)
  EMPU(A,N) = EMCON(A,N) + EMCSE(A,N) + EMGOB(A,N)
8 CONTINUE
  RETURN
  END
```

```
EMCON(A,N) - EMPLOYMENT CIVIL CONSTRUCTION, PROGR. AREA A, YEAR N
VACSE(A,N) - ADDED VALUE COMMERCE AND SERVICES, PROGR. AREA A,
             YEAR N
EMGOB(A,N) - EMPLOYMENT GOVERNMENT, PROGR. AREA A, YEAR N
RMOCO(N) - LABOUR REQUIREMENTS PER UNIT OF PRODUCT, CIVIL
           CONSTRUCTION, YEAR N
RMOSE(N) - LABOUR REQUIREMENTS PER UNIT OF PRODUCT, COMMERCE
           AND SERVICES, YEAR N
RMOGO(N) - LABOUR REQUIREMENTS PER UNIT OF PRODUCT, GOVERNMENT,
           YEAR N
VAPCSC(A,N) - ADDED VALUE TERTIARY SECTOR, PROGR. AREA A, YEAR N
EMPU(A,N) - EMPLOYMENT TERTIARY SECTOR, PROGR. AREA A, YEAR N
```

****

APPENDIX II

PROJECTS AND ACTIONS CONSIDERED IN THE DEVELOPMENT PLAN FOR THE UPPER PARAGUAY RIVER BASIN

APPENDIX II

PROJECTS AND ACTIONS CONSIDERED IN THE DEVELOPMENT PLAN FOR THE UPPER PARAGUAY RIVER BASIN

A) GOALS AND OBJECTIVES

1. The regional development plan deals exclusively with the following sectors:

   - Agriculture and cattle-raising
   - Agroindustry and mining
   - Transport infrastructure
   - Electric power infrastructure
   - Health services and sanitation
   - Basic education, and
   - Urban development

2. The programme for the agriculture and cattle-raising sector aims to achieve the following goals by the fifth year of the Plan.

   a) Extend the area under cultivation (in 1980) by 638,978 hectares;

   b) Extend the area of planted pasture by 923,152 hectares;

   c) Maintain moderate growth rates of the cattle stock , which should increase by 2,334,129 head in the quinquennium;

   d) Change the structure of agricultural production,reducing the relative importance of rice;

   e) Increase the physical yields of all the crops and the cattle stock;

   f) Increase the volume and value of cattle-raising production. By year 5 the value of production will have increased by CR$ 19,870 million in relation to production in 1980.

The following activities are planned in support of the rural economic sector: credit, technical assistance and storage of grain. It is proposed to integrate credit and technical assistance at the level of rural establishments. The proposed programme aims by year 5 to:

a) Provide assistance to 15,203 rural establishments in addition to those who benefited in 1980 from the services of the technical assistance institutions in the region;

b) Radically change the "profile" of the beneficiaries, so that 58% of those assisted will be establishments with a total area of less than 20 ha and 84% less than 200 ha;

c) Increase by 209 technical assistants and 28 senior technicians the present number of staff of EMATER (MT) and EMPAER (MS) and organize intensive courses for 75% of the technical assistants to be incorporated during the five-year period;

d) Give the 15,203 establishments mentioned in item a) access to rural credit schemes; the resources to be provided for this purpose are additional ones, specifically linked to the objectives of the Plan;

e) Extend the region's capacity for the storage of grain through the construction of silos on farms so as to almost entirely eliminate the deficits forecast for year 5. To this end, the construction of a total of 1,225 silos is proposed (704 of 100 tons, 490 of 500 tons and 31 of 1,000 tons) amounting to an additional static capacity of 346.400 tons for the five-year period.

3. The planned agro-industrial activity aims to substantially increase the region's capacity to process raw materials from agriculture and cattle-raising. The following additions to existing capacity are specifically proposed:

a) Meat - The construction of 3 cold-storage abattoirs for the slaughter of 270,000 head of cattle per year;

b) Milk - The construction of six plants to process 43.8 million litres of milk per year;

c) Rice - The construction and/or enlargement of 63 units for processing 560,000 tons of rice in the husk, per year;

d) Soy - The construction of 3 units for the annual industrialization of 605,000 tons of raw material;

e) Animal feed - The establishment of 7 processing plants with a total production capacity of 43,680 tons of concentrates and balanced feed;

f) Babassu - The construction of 2 units for making full use of babassu, with an expected 80,000 tons of raw material being processed per year, basically intended for the production of alcohol.

In addition, consideration is being given to increasing by 792,000 tons p.a. the region's capacity for grinding calcarium for soil correctives.

4. The transport programme is concentrated on the road subsector. It is proposed to improve 3,670.5 km of roads: 745.5 km are to be surfaced, 1,693 km are to be improved and 1,232 km of local roads are to be built. Pre-investment studies are also proposed for improving the efficiency of rail and fluvial transport.

5. Reference was made in EDIBAP's 1st Phase Report to the problems of the insufficiency and unreliability of electric power supplies. The Report also contained a number of recommendations for solving the problems identified . After its publication the government took some highly important decisions on this subject. These were: the extension

of long-distance transmission lines to ensure electricity supplies with energy imported from the neighbouring states, the construction of the Manso hydroelectric power station and the building of a thermoelectric plant at Corumbá.These works will be sufficient to meet regional demand until the early nineties.

In these circumstances the programme, in addition to proposing more thorough studies to define some medium-term alternatives for the generation of electric power, only provides for the construction of 138 and 345 KV transmission lines for supplying the southern part of the Bodoquena programme-area and pre-investment studies for the elaboration of mini-hydroelectric power station projects.

6. The health programme aims to expand unsophisticated schemes of medical care, to be complemented by the intensive training of personnel. The proposal includes:

   a) The construction and equipping of 70 health posts in the rural districts with a total constructed area of 4,600 m^2;

   b) The construction and equipping of 14 health centres and 3 mixed units in the municipalities that do not possess this kind of unit: a total constructed area of 5.000 m^2;

   c) The training of 46 high-level an 272 middle and elementary level paramedical personnel.

   As far as basic sanitation is concerned, the programme gives priority to assisting 53 rural districts; it proposes to connect 5754 homes to a mains water supply and install 7,505 water-closets provided with cesspits.

   The education programme aims to extend elementary education over a wider area and to improve its quality. To this end it is proposed to:

a) Construct and equip 212 one or two-room rural schools, a total of 303 classrooms in all;

b) Construct two centres of educational technology, one in Cuiaba, the other in Campo Grande, each with an area of 740 m^2, for the purpose of creating and activating resources to assist teachers in elementary schools and

c) Train 606 new elementary school teachers.

In addition, the programme includes the construction and equipping of an Agricultural College in the municipality of Rio Verde (Alto-Taquari programme-area). This is expected to produce 50 skilled personnel per year from its third year of operation.

Finally, it is proposed to undertake studies with a view to updating the curricula of primary and secondary education.

7. The programme of urban development aims to raise the quality of public services in some towns and increase the urban utilities in selected centres. The proposal includes:

   a) Expansion of the water supply systems in the largest towns, increasing storage capacity by 30,000 m^3, supply capacity by 676 litres/second and the number of homes connected to mains by 83,800;

   b) a 76,600 increase in the number of homes connected to a sewage system in the most populous zones of the main towns in the region;

   c) a 79,660 increase in the number of homes supplied with electricity in the same towns and

   d) an Extension of the basic urban services.

B) INVESTMENTS

1. The total value of the investments due to be made by the sectorial programmes during the quiquennium is 57,101.1 million cruzeiros (at April 1980 prices), divided equally between the north and south of the region (see Table 1). Almost 50% of the total comprises investments in agriculture and cattle-raising establishments, 20% for road building and improvement and just over 16% for investments in industry.

2. It should be emphasized that the investments in the transport sector do not include the current annual cost of road maintenance. The investments in industry for their part, include the initial requirements of the proposed plants for operating capital. The private sector investments induced by government action and by the development of the regional activities foreseen in the Plan, were excluded from the item "Urban Development". This is because a part of these investments will take effect outside the period of the Plan. Moreover, it is difficult to establish efficient mechanisms at government level to supervise the implementation of such investments.

3. The time scale of the total investments for the quinquennium, sectorially disaggregated, is shown in Table 2. Almost 15% of the total corresponds to year 1 of the implementation of the Plan and 23% to each of the following two years, the rest is distributed in similar fashion over the final two years of the quinquennium.

4. The investments in the agriculture, storage, and industry and mining sectors will be made by the private sector. On the other hand, the investments in transport, energy, education, and health and sanitation are the responsibility of the relevant official organs. Accordingly, the joint participation of the private sector and

TABLE II.1

TOTAL PLANNED INVESTMENTS FOR THE QUINQUENNIUM
(10^6 CR-1980)

	NORTHERN SUB-REGION	SOUTHERN SUB-REGION	REGIONAL TOTAL
AGRICULTURE AND CATTLE-RAISING	13 125,0	12 107,8	25 232,8
STORAGE	1 904,1	890,0	2 794,1
INDUSTRY AND MINING (1)	4 504,3	5 133,6	9 637,9
TRANSPORT (2)	4 873,3	6 628,8	11 502,1
ENERGY	100,0	680,0	780,0
HEALTH AND SANITATION	189,2	113,2	302,4
EDUCATION	237,8	228,3	466,1
URBAN DEVELOPMENT	3 952,5	2 799,2	6 391,7
TOTAL	28 526,2	28 580,9	57 107,1

(1) Includes operating capital

(2) Does not include annual costs of road maintenance

TABLE II.2

TIME SCALE OF THE TOTAL INVESTMENTS IN THE REGION FOR THE QUINQUENNIUM DESAGGREGATED BY ACTIVITY

(10^6 CR - 1980)

ACTIVITY YEAR	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	REGIONAL TOTAL
AGRICULTURE AND CATTLE-RAISING	4 138,2	4 592,4	5 021,3	5 475,5	6 005,4	25 232,8
STORAGE	-	1 526,0	480,2	416,5	371,4	2 794,1
INDUSTRY AND MINING	621,7	2 713,4	3 457,7	1 869,4	975,7	9 637,9
TRANSPORT	2 326,8	2 237,7	2 273,5	2 346,9	2 317,2	11 502,1
ENERGY	100,0	400,0	280,0	-	-	780,0
HEALTH AND SANITATION	164,3	109,5	28,6	-	-	302,4
EDUCATION	108,5	195,6	162,0	-	-	466,1
URBAN DEVELOPMENT	1 205,7	1 371,4	1 444,5	1 138,5	1 231,6	6 391,7
TOTAL	8 665,2	13 146,0	13 147,8	11 246,8	10 901,3	57 107,1

official organs is foreseen only in the execution of the urban development programmes.Consequently, direct, planned public investment comes to 19,048.80 million cruzeiros (at April 1980 prices), a figure that represents one third of the total forecast for the region.

C) MAIN SOURCES OF RESOURCES

1. The loans it is considered possible to obtain, using in almost every case currently existing lines of credit, are indicated below for each sector of activity.

2. Agriculture and cattle-raising sectors

   It is proposed to finance the total value of the investments of small producers, 80% of the value for medium-size producers and 60% for large producers. This criterion implies making available investment loans to the tune of 17,307.9 million cruzeiros (at April 1980 prices), a figure that represents 69% of the total investments contemplated for the agricultural and cattle-raising sector.

3. Storage

   In accordance with the norms of PRONAZEM (National Storage Programme) it is proposed to finance the total value of the investments in the construction of silos of 100 tons, 90% in the case of 500-ton silos, and 80% for 1,000-ton silos. Consequently, the loans required for the quiquennium amount to 2,583.4 million cruzeiros (93% of the total planned investments).

4. Industry and Mining sector

   Some proposed industries benefit from government fiscal incentives. In addition, there are various bank loans provided for agro-industry. The result of an analysis of the possible sources of loans for each type of industry led to the following profile of sources of resources:

a) Fiscal incentives: 1,390 million cruzeiros

b) Investment banks: 5,370 million cruzeiros
Total: 6,760 million cruzeiros

This sum represents 70% of the total planned investments.

5. Transport sector

The following table shows the value of investments in the transport sector and the suggested sources of loans.

TABLE 3

TRANSPORT SECTOR: SOURCES OF LOANS FOR THE INVESTMENTS OF THE QUINQUENNIUM

PROGRAMMES	INVESTMENT	SOURCES OF LOANS			
		BIRD	BNDE	DNER	DERMAT. AND DERSUL
Road surfacing	2 993,3	-	-	-	2 993,1(*)
New roads to be built	5 649,6	1 853,1	2 090,3	576,3	1 129,9
Improvement of local roads	2 859,2	937,8	1 057,9	291,6	571,8
Total	11 502,0	2 790,9	3 148,2	867,9	4 695,0

(*) The PROMAT, PROSUL and POLOCENTRO special Programmes are also considered as sources of resources

6. Electric power sector

It is suggested that the pre-investment studies to develop the programme of mini-hydroelectric power station be financed entirely by ELETROBRAS (200 million cruzeiros). The laying of the transmission lines in the southern part of the Bodoquena programme-area was regarded as part of the normal programmes of ENERSUL, partially financed by ELETROSUL.

7. Health and sanitation sector

It is proposed that the state governments be responsible for about 35% of the investments foreseen in the programme, the federal government funding the remaining 65% with resources from the Ministry of Health (for the establishment of Health Units), the Ministries of Education and Labour (for the training of personnel) and Ministry of the Interior (for basic sanitation). In these circumstances, the scheme for financing the health programme is as follows:

a) State governments :	104.9 million cruzeiros
b) Ministry of Health:	153.6 million cruzeiros
c) Ministries of Education and Labour	5.8 million cruzeiros
d) Ministry of the Interior	38.1 million cruzeiros
Total	302.4 million cruzeiros

8. Education sector

Here also a sizeable participation of the federal government in the financing of the programme is proposed, as specified below:

a) Ministry of the Interior:	288.4 million cruzeiros
b) Ministry of Education:	36.7 million cruzeiros

c) SUBIN:	1.5	million cruzeiros
d) FAS/CEF (Federal Savings Bank):	139.5	million cruzeiros
Total:	466.1	million cruzeiros

9. Urban Development

The planned investments comprise 3 different categories:

a) Sanitation (supply and distribution of drinking water and sewage systems). Just over 45% of the investments are to be financed by the users. The remainder will come from SANEMAT's and SANESUL's own resources, supplemented by funds from PLANASA (National Plan of Sanitation).

b) Urban electrification. One third of the investment costs will be directly financed by the users. The remainder should be financed initially by CEMAT and ENERSUL, and subsequently with funds from the tariffs of the new services.

c) Other investments in urban infrastructure. This category includes investments such as offices for federal, state and municipal organs; and community facilities such as green areas, sports fields, secondary and technical schools, university facilities, special health services, etc.

The construction of the offices for the official organs will be financed by the government bodies themselves. The remainder of the resources should come from the federal government through the Ministries of the Interior, Education, Health and Labour.

APPENDIX III

MODEL VALIDATION AND ANALYSIS OF RESULTS

MODEL VALIDATION AND ANALYSIS OF RESULTS

This appendix contains a brief discussion of some technical aspects of the model, an assessment of its results and also an explanation of the type of analysis carried out for its calibration.

1. Validation of the model

As explained in Chapter 3 model validation is a leng~~h~~thy and quite complex procedure that involves two basic stages. In the first stage it is determined if the model is consistent in a logical and programming sense, while the second stage is devoted to determine the degree in which the model represents the phenomena it should represent. For eas of exposition these two types of analysis are presented separately.

1.1 Consistency of the model

The first step of the validation process is characterized by the study of the model's consistency both in terms of its internal logic (theoretical background) and the accuracy of its calibration and algorithm.

To the extent that the algorithm is the mathematical procedure for solving (or simulating) the model, it is included in the computer programme utilized. Usually the assessment of the computer programme is considered of lesser interest when compared with the theoretical content of the model. In fact, there exists a generalized idea that computer programmes are always correct and that programming is a secondary technical aspect of modelling. Nevertheless, when dealing with a complex model it is necessary to bear in mind that programming requirements may introduce simplifying assumptions additional to those theoretical ones that underlie the structural form of the model . This aspect is frequently neglected when explaining a model. In our case, however, lack of information is to be regarded as the main factor responsible for the introduction of simplifying assumptions into the model. Thus, no special restrictions derived from the computer programme have to be reported.

For testing the consistency of the model with its theoretical background analysis was restricted to a few relevant aspects. Due to the fact that the composite model (i.e. the integrating framework of partial submodels) was designed as an accounting device to aggregate partial results and as the control mechanism of the algorithm of the complete model, it was assumed that it has no problems of theoretical consistency, because it only comprises identities. Thus it was judged that an adequate test of its validity would be a comparison of the model's output with empirical data. In this way consistency analysis was carried out for the behavioural equations in the submodels. Let us see its main conclusions.

a) Demographic and employment submodel

This submodel is composed of 17 identities and 6 behavioural equations. Five behavioural equations refer to the explanation of net migration rates and one deals with the coefficient of rural population.

With regard to the way in which the model explains net migration, two main problems of consistency were identified. They refer to the quantification of the variables included in the function and to the possibility of omission of some important explanatory variables.

On the one hand, net migration rates were quantified by means of an indirect procedure and total employment growth rates were obtained as annual average rates for a period of ten years. Thus, values of the dependent variable are not observed values but estimations which naturally may contain certain deviations with regard to the real phenomenon they represent while the dependent variable reflects the tendency of total employment during a decade omitting short term variations.

Since lack of information prevented the use of more accurate methodologies for such estimations, the values thus obtained have to be considered as acceptable ones, although they might induce some distortions in the model's results.

Perhaps the most important source of distortions derives from the fact that behavioural equations are calibrated with cross-section data representing annual averages for the period 1960-1970 and then used to forecast annual net migration rates from 1980 onwards. Here two basic problems can be distinguised. Firstly as averages tend to be more stable than individual observations, there is the danger that extreme values of the independent variable may lead to unrealistic net migrations rates (this aspect is discussed in section 3).
Secondly , the use of a function calibrated on cross - section data for forecasting purposes assumes that the relationship between the variables included in the function and all those relevant variables excluded will remain constant, for the whole forecasting period. Since there is a time lag of at least 15 years between the base year and the projected ones, it is doubtful that such constance would be maintained, especially since the function excludes many variables that have theoretical relevance in the explanation of net migration.

On the other hand the type of function utilized for explaining the behaviour of the migration rates is very simple and contains only one independent variable. As such it neglects many factors that may contribute to explain this phenomenon.. Unfortunately lack of information prevented the use of a more complex function. However, in spite of the theoretical limitations of the linear function tried, regression analysis provided fairly good statistical tests with R^2 above 0,90, Student t test for parameters and F tests significant at 99% confidence level. (See Table 4.4)

Thus it can be concluded that, although the function utilized omitted many explanatory variables, at least it explains more than 90% of the variation in the dependent variable, which means that the error included is relatively small.

The rural coefficient function, for its part, does not present significant problems of consistency, except the fact that it was calibrated on cross-section data and used for predictive purposes.

b) Economic Submodel

b.1 Agricultural sector

This sector of the economic submodel includes 15 identities and 4 behavioural functions. Here the critical problem of consistency is referred to the explanatory function of the expansion of the agricultural frontier.

In fact, some problems arise when quantifying the behavioural function. Initially a quantification based on a time series was tried but it was disregarded because of lack of information . Thus regression analysis was performed on cross-section data for the year 1975 with highly significant results (R^2 = 0.99; and highly significant Student t test for parameters and F-Test. See equation AGR-1).

As mentioned above, a function fitted on cross-section data entails that the linear relationship that exists between the variables at the observed level will remain constant for higher values of such variables.

In this case, it is reasonable to assume that the amount of land devoted to agriculture and cattle raising will increase to the extent that the road network and the amount of loans granted for these activities increase, especially if the area under study presents a low level of utilization of its natural resources. But, as the level of use of avaiable land aproximates to the total area suitable for agriculture and cattle raising, land under present use is not likely to react in the same proportion to increments in the road network and credits granted.

Thus as the density of roads or the amount of credits per unit of utilized land reaches certain limits it is reasonable to assume that the form of the behavioural function ceases to behave linearly.

In order to prevent overestimation of the expansion of the agricultural frontier the model includes an ecological constraint that impedes allocation of land to these activities be yond a certain limit. Although this procedure proved quite useful in the simulations, it must be recognized that the model is likely to overestimate the expansion of the agricultural frontier in those programme areas of higher density.

For a more accurate treatment of this problem a dummy variable related to road density is likely to constitute the best solution, but it was not possible to test due to constraints on time.

b.2 Cattle raising sector

As known, the evolution of any herd of cattle depends on three basic factors; birth, mortality and extraction rates. Birth and mortality rates were defined exogenously and assumed as constant for the simulation period, thus, the model only explains the rate of extraction. For modelling purposes this factor was divided into two subfactors, namely extraction for slaughter and the transfer of cattle between programme areas.

For explaining extraction for slaughter an agricultural supply function was utilized which is highly consistent with traditional assumptions of supply theory. The main problem of consistence here derives from the procedure utilized for quantifying the dependent variable.

As reported in section 5.3, due to lack of information it was necessary to use an indirect procedure (which involved many assumptions) to estimate extraction rates for slaughter.

For testing these estimates the cattle sector of the model was simulated for reproducing the evolution of the regional stock of cattle between the agricultural censuses of 1960, 1970 and 1975, using fixed rates of birth and mortality. This procedure was repeated until a series of extraction rates that reproduced the observed evolution of cattle stock was obtained. Thus, although the model reproduced adequately real world behaviour it is possible that extraction rates may include(or exclude) some distortions attributed both to the estimated birth and mortality rates. In this way there is some inconsistency in explaining part of the natural growth of cattle in terms of a supply function or the contrary. This naturally might lead to certain errors in the estimations of the product generated by cattle raising but as available information did not allow a better treatment of this function, these results were regarded as acceptable for the purposes of EDIBAP.

The explanatory function of cattle transfers between programme areas did not present significant problems of consistency with regard to theoretical considerations.

b.3 Industrial and tertiary sectors

These two sectors of the economic submodel comprise 11 identities and 5 behavioural equations. Two of these explanatory functions are hypothetical behavioural equations calibrated with only two observations(functions explaining added value of civil construction and government activities). As such they can not afford any statistical testing and have to be regarded as assumptions underlying the model.

The explanatory function of the timber industry for its part did not present problems of consistency with regard to its internal logic but produced unrealistic results for low values of the dependent variable. Since this problem is more related to sensitivity analysis it is discussed in section 2 of this appendix. The other two behavioural equations are consistent with the treatment given by export base theory to non basic sectors (residential activities) and also calibration provided highly significant results.

c) Environmental and physical submodel

This submodel does not contain behavioural equations, except the transport sector . Thus, excluding this sector, it is assumed to be consistent to the extent that the results of the composite model reproduce the main features of the real system with reasonable accuracy.

The transport sector, for its part, was designed for giving priority to road projects, defined exogenously. In this way its output is fed into the composite model as an exogenous variable (amount of investment in roads) and does not affect the internal logic of the overall model.

2.2 Results of the model and empirical observations

The second step of validation involves comparisons between the model's output and real world data for determining how it represents real phenomena.

This is a very difficult task since as Van Horn has put it, " one reason for building simulators is to explore situations for which no empirical data exist. In this event, the inferences represent extrapolation from the experience base. The experimenter must now ask whether his insight applies to a property of the actual process or merely to a pecualiarity of the simulation that only affects the extrapolated situation. There is no answer to this question in the simulation situation. If the modeller w ishes to further increase confidence, he must look outside" (VAN HORN, 1969, p. 242).

In our case the main problem of comparing the model's results with empirical observations deals with the fact, that the relevant results of the model refer to the future and obviously there exists no way to perform such comparison. For practical purposes this second step of the validation process is devoted to the assessment of the way in which the model represents the current situation of the system under study.

When sound statistical data are available or when it is possible to carry out experiments, some data or empirical observations are excluded from the calibration of the model and used for its validation. In our case, such a procedure was inadvisable because, if some of the few available observations were excluded from regression analysis of behavioural equations, the degrees of freedom of the model would be drastically reduced. This would lead to a higher variance and, therefore, to a lower precision of the model's predictions.

In this way, some behavioural equations were calibrated with time series data from 1965 up to 1978 and others with twelve cross-section observations for 1970 or 1975. At the moment of writing this appendix, only a little general information of the Demographic Census of 1980 was available (economic censures are currently in the stage of data collection).

Thus in performing comparisons between the model's output and real data we can only use scattered data for a certain variables between 1975 and 1980.

Tables III.1 and III.2 present some available empirical information regarding a few endogenous variables of the model and their simulated counterparts. Although the model reproduces real world phenomena with an impressive degree of accuracy it is necessary to point out that these results are the outcome of a lenghty trial and error process that involved a great number of simulations. Such a process led to many adjustments both of the structure of the model and of the information utilized for the base year of simulations.

These adjustments were particularly important in the case of the demographic submodel and this is the reason why the model predicts so well the regional population for 1980.

For simulations of the composite model, 1975 was adopted as the base year, therefore the population for each programme area disaggregated by sex and age cohort for that year was defined exogenously. In order to obtain such population the demographic submodel was initially calibrated on data derived from the census carried out in 1970 and run up to 1975. The projected population thus generated was utilized as base year information for the simulations.

Information from the census of 1980 was available when the model was ready and its results presented a systematic overestimation of population per programme area (around 7 %). Since the model was designed to simulate the behaviour of the regional system from 1980 onwards, it was judged necessary to reduce the magnitude of the error for 1980 because it may become too big for the simulations for 1985 and 1990.

Thus two modifications were performed in the exogenous variables. First the estimated population for the base year (1975) was replaced by the average population obtained from the censuses of 1970 and 1980. Second, fertility rates were reduced. These rates were obtained from empirical studies carried out for the period 1960-1970 (COSTA,1976), and official forecasts based on such fertility rates also predicted at the national level a greater population for 1980 than that provided by the census. Thus, unofficial preliminary estimations of fertility rates for the seventies were utilized.

In the other submodels the most significant deviation between real data and those obtained from simulations corresponds to the estimation of cattle stock for Mato Grosso do Sul in 1975, especially in the case of the programme-area of Corumbá. On studying this problem it was detected that years 1973 and 1974 were excessively wet and that the "Pantanal" (swamp area of Corumbá) suffered the worst flood since 1959.

As a consequence of this phenomenon land available for cattle raising was drastically reduced and farmers reacted, reducing their herds by selling animals both to other programme areas and to slaughter-houses. Since the model does not account for this type of phenomena, such deviations must be regarded as acceptable.

From another view point tables III.1 and III.2 show that the model produces better results for the whole region than at the programme-area level. This is natural since, on the one hand larger samples tend to present a more stable behaviour than smaller ones due to the lower incidence of unexpected changes of exogenous variables and On the other hand because some behavioural equations were calibrated on empirical data for the whole region and then disaggregated at the programme area level.

Finally, it would be useful to have a statistical measure of the goodness of fit between real and simulated data, however the absence of stochastic variables in the simulations makes incorrect the use of any type of correlation coefficients.

TABLE III.1

STATES OF MATO GROSSO AND MATO GROSSO DO SUL

COMPARISON OF MODEL'S RESULTS AND AVAILABLE DATA FOR AGRICULTURE

YEAR	TOTAL AREA DEVOTED TO CROPS		AREA DEVOTED TO RICE AND SOY BEANS	
	Statistical Yearbook	Simulated	Statistical Yearbook	Simulated
1975	1,519,832	1,428,044	967,275	863,412
1976	2,231,938	2,112,685	1,684,375	1,559,010
1977	2,515,571	2,314,919	1,958,785	1,741,239
1978	2,376,300	2,540,093	2,017,911	1,995,931

In fact, Howrey and Kelejian demonstrate that in non-stochastic simulations " the difference between a particular element of Y_t and the corresponding element of $\hat{Y}_t^*$ is a disturbance term which is both autocorrelated and heteroskedastic. Therefore the relationship between such elements should not be studied in terms of simple correlation analysis" (*). This finding le d these authors to conclude that "once the classical regression tests concerning the parameters and the residuals of an econometric model have been carried out, the results of further tests of the model via comparison of linear functions of historical and simulated values of the endogenous variables over the period of estimation contain no aditional information concerning the validity of the model..... Moreover , if observations outside the period of estimation are available, tests of the model using such information should be conducted in terms of the known multivariate distri

(*) For these authors Y_t represents the historical values of the endogenous variables and $\hat{Y}_t^*$ their simulated counterparts.

EMPIRICAL OBSERVATIONS AND MODEL'S RESULTS

PROGRAMME AREAS	TOTAL POPULATION 1980		AREA DEVOTED TO RICE AND SOY BEANS 1978		STOCK OF CATTLE 1975	
	Demographic Census	Simulated	Statistic Yearbook	Simulated	Agricultural Census	Simulated
1.Alto Paraguay	91,974	91,342	49,292	56,724	316,942	163,446
2.Caceres	161,878	160,515	57,055	66,272	346,707	334,545
3.Cuiabá	477,171	472,522	65,725	74,675	885,140	858,748
4.Rondonopolis	200,409	199,412	99,333	117,225	696,823	664,566
5.Barra do Garças	122,670	122,645	62,899	71,100	631,516	615,206
6.Diamantino	94,208	93,595	35,862	36,959	232,991	248,304
STATE OF MATO GROSSO	1,148,310	1,140,061	370,166	422,955	3,110,119	2,885,315
7.Alto Taquari	85,933	85,394	144,275	164,464	656,174	828,097
8.Campo Grande	352,680	347,036	282,091	322,651	763,796	950,160
9.Bodoquena	94,862	94,314	94,178	105,586	1,155,460	1,065,472
10.Corumbá	124,138	120,083	2,440	2,563	2,484,660	3,026,712
11.Tres Lagoas	163,673	162,826	122,494	140,898	1,157,101	1,287,902
12.Dourados	540,309	534,701	1,002,267	836,814	2,653,963	2,474,582
STATE OF MATO GROSSO DO SUL	1,361,595	1,344,354	1,647,745	1,572,976	8,871,154	9,632,925
TOTAL REGION	2,509,905	2,484,415	2,017,911	1,995,931	11,981,273	12,518,240

bution theory concerning forecasting and not in terms of ad hoc comparisons between historical and simulated values of the endogenous variables". (HOWREY and KELEJIAN, 1969, pp. 210-211).

In our case the only available information not utilized for estimating the model is that provided by the Demographic Census of 1980. However, since the demographic submodel was "specially re-calibrated" to fit such data, they become useless for further testing the validity of the model. Thus, although the reasons presented above prevented the use of statistical measures of the goodness of fit between empirical and simulated data, the model was judged acceptable for the purposes of EDIBAP since it reasonably represents historical behaviour of the main variables of the regional system and because its projections provide values within the expected range of magnitude.

2. Sensitivity Analysis

After estimating and validating the model a large number of partial simulations were carried out for testing the sensitivity of each submodel with regard to changes of parameters and also in relation to changes in the value of exogenous and policy variables.

Altogether 132 partial runs were performed which, for reducing computer costs, consisted of simulations of individual submodels for a single programme area (*). These were complemented by more than 20 experimental runs of the whole model specially designed for testing interdependence relationships between submodels and also to study the effects of critical

(*) In order to study the effects of ecological constraints and other limits introduced for stabilizing the model, sensitivity analysis of each submodel was carried out for the programme-area where such constraints constitute effective limitations for the simulations. In this way the demographic submodel was simulated for the programme-area of Diamantino, agricultural and cattle raising submodels were run for Alto Taquari and industrial and tertiary activities submodels for the programme area of Caceres.

values of policy variables on the behaviour of the composite model.

In order to provide a homogeneous treatment of all submodels sensitivity analysis was carried out for changes of parameters of behavioural functions equal to one standard error of estimate and for changes of 10% of exogenous and policy variables. Futhermore the effects of these changes were assessed in terms of the induced variation on a few aggregate endogenous variables and expressed as a percentage of the corresponding base run value.

The following pages contain the main findings of sensitivity tests carried out for each submodel.

2.1 Demographic and employment submodel

This submodel contains six behavioural equations that comprise 12 parameters. Five equations are simple linear functions that explain net migration rates in terms of the rate of growth of total employment in the previous year. Table III.3 summarizes the effects of changes of these functions parameters on total population and active age population. Because of the structure of this submodel net migration functions do not affect the distribution of total population into urban and rural components.

The slope of the net migration function for population under 15 years of age (b1) is the parameter that presents the greater effect on total population forecasts. In fact, an increment of one standard error of estimate (9.68% of the normal value) induces a 6.6% increase of total population by 1990. This means an elasticity coefficient of 0.68 which is to be regarded as relatively high.(*)

(*) As known elasticity coefficients are a relationship between the variation of the response variable and the parameter change. In mathematical terms it is represented by:

$$E_p = \frac{\frac{\Delta X}{X}}{\frac{\Delta P}{P}}, \text{ where } \begin{array}{l} X = \text{response variable} \\ P = \text{parameter} \end{array}$$

A negative value of the elasticity coefficient denotes an inverse relationship between parameter and reponse variable.

TABLE III.3

MOGRAPHIC AND EMPLOYMENT SUBMODEL. SENSITIVITY ANALYSES OF CHANGING PARAMETERS OF BEHAVIOURAL FUNCTIONS

HAVIOURAL FUNCTIONS :

T MIGRATION RATES

NMR(S,E,A,T) = - ai + bi * CREMP(A,T-1) (*)

RAL - URBAN COEFFICIENT

CPR(A,T) = c* (PEP(A,T-1)^{d}

METER CHANGE (**)	PERCENT COMPARISON OF PROJECTIONS WITH BASE RUN					
	TOTAL POPULATION		ACTIVE AGE POPULAT.		RURAL POPULATION	
	1985	1990	1985	1990	1985	1990
BASE RUN	0	0	0	0	0	0
a1 + s.e	- 2.11	- 2.89	- 0.87	- 1.59	0	0
a1 - s.e	+ 2.20	+ 3.05	+ 0.90	+ 1.67	0	0
b1 + s.e	+ 5.12	+ 6.60	+ 2.41	+ 4.05	0	0
b1 - s.e	- 4.60	- 5.82	- 2.21	- 3.63	0	0
a2 + s.e	- 0.97	- 1.29	- 1.65	- 2.17	0	0
a2 - s.e	+ 1.00	+ 3.14	+ 1.70	+ 2.26	0	0
b2 + s.e	+ 2.31	+ 2.89	+ 3.99	+ 4.87	0	0
b2 - s.e	- 2.19	- 2.63	- 3.71	- 4.43	0	0
a3 + s.e	- 1.00	- 1.56	- 1.07	- 1.47	0	0
a3 - s.e	+ 1.03	+ 1.60	+ 1.11	+ 1.55	0	0
b3 + s.e	+ 2.50	+ 3.59	+ 2.56	+ 3.29	0	0
b3 - s.e	- 2.34	- 3.31	- 2.38	- 3.01	0	0
a4 + s.e	- 0.37	- 0.48	- 0.45	- 0.55	0	0
a4 - s.e	+ 0.40	+ 0.53	+ 0.49	+ 0.60	0	0
b4 + s.e	+ 0.93	+ 1.11	+ 1.09	+ 1.20	0	0
b4 - s.e	- 0.77	- 0.88	- 0.91	- 0.98	0	0
a5 + s.e	- 0.07	- 0.09	- 0.09	- 1.07	0	0
a5 - s.e	+ 0.07	+ 0.09	+ 0.08	+ 1.07	0	0
b5 + s.e	+ 1.61	+ 0.19	+ 0.19	+ 0.21	0	0
b5 - s.e	- 1.48	- 0.17	- 0.18	- 0.19	0	0
c + 10%	0	0	0	0	- 7.87	- 7.87
c - 10%	0	0	0	0	+ 3.30	+ 3.30
d + s.e	0	0	0	0	+ 74.04	+ 69.08
d - s.e	0	0	0	0	- 41.88	- 40.85

i = 1 correspond to males and females under 15 years of age
i = 2 correspond to males between 15 and 49 years of age
i = 3 correspond to females between 15 and 49 years of age
i = 4 correspond to males over 49 years of age
i = 5 correspond to females over 49 years of age

All parameter changes were equal to one standard error of estimate of the para meter involved, except c that was changed in 10%

In relation to active age population the slope of the net migration function for males between 15 and 49 years of age(b2) is the parameter that presents the greater effect with an elasticity coefficient of 0.68 for positive variations and 0.62 for negative changes.

The behavioural equation of the rural population coefficient, for its part, is an exponential function and, therefore, it is very sensitive to parameter changes. As expected the effects of the exponent (d) are far more important than those of parameter c. This last presents an elasticity coefficient of -0.79 for positive changes and -0.33 in the opposite situation. The negative sign of the elasticity coefficient derives from the fact that it is the antilogarithm of a negative number, thus to the extent that such number increases in absolute terms its antilogarithm decreases.

Elasticity coefficients for parameter d, measured in terms of rural population for 1990, range from 5.53 in case of positive variations to 3.27 for negative changes. Obviously such high coefficients reflect that this is a critical parameter of the demographic submodel and that further study is recommended for obtaining a more stable function(*).

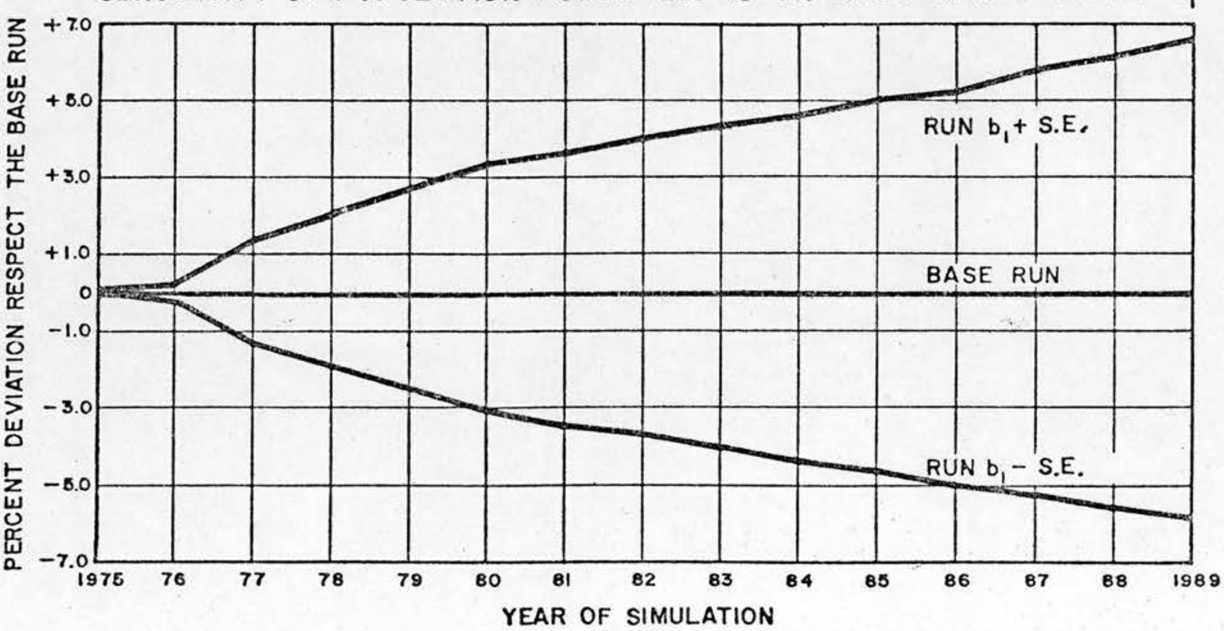
Although the submodel is relatively sensitive to parameter changes, estimation of such parameters, yielded small standard errors and consequently high student "t" tests. This means that there is a high probability that the estimated values correspond to true ones, which provides the model a greater level of confidence. In fact, narrow confidence intervals for all parameters (except c) explain that in total population forecasts the greater deviation (due to parameter changes equal to one standard error) reaches only 6.6% of the corresponding base run value in a fifteen year period. Naturally this is to be regarded as satisfactory for this type of model.

(*) A simple linear function for this behavioural equation was disregarded because it presented some inconsistency for extreme values of the independent variable (See Chapter 4, section 4.1.2).

Two reasons explain the significant incidence of this parameter on population forecasts. On the one hand this function is applied to the most numerous cohorts of regional population - (42,7% of total population in the base year). On the other hand the demographic submodel is accumulative. This is to say that a population forecast for a given year is utilized as base information for calculating the population of the next year. In this way any change derived from modifications of parameters or exogenous variables aggregate through the whole forecasting period leading to a continuous growth of the initial deviation (See Fig III.1). This accumulative behaviour also accounts for the asymmetry of the effects of changes in the parameters of net migration functions, positive effects are always greater than negative ones.

FIG. III.1

SENSITIVITY OF POPULATION FORECASTS TO CHANGES IN PARAMETER b_1



The Sensitivity of the demographic submodel to exogenous variables (including variables generated by other submodels) presents a double pattern. It is very stable in relation to changes in fertility and survival rates but highly unstable with respect to variations of employment growth rates and primary employment/total employment ratio (See Table III.4).

A 10% increase of fertility rates led to a 3,52% variation in total population and 0.75% of active age population in 1990 (elasticity coefficients of 0.35 and 0.08 respectively). Survival rates, for their part, have a lower effect on both endogenous variables with elasticity coefficients of 0.12 and 0.07.

The rate of growth of total employment is a very critical variable since its impact on total population and active age population forecasts is greater than the joint effect of parameters b1, b2, b3, b4 and b5. Moreover, as this variable is generated by the composite model and fed back to the demographic submodel for the next year of the simulation, any deviation derived from normal errors of this type of model may lead to increasingly divergent demographic forecasts.

The Primary employment/total employment ratio presents a similar situation. Because of the importance of these variables for assuring a convergent behaviour of the overall model, they are studied in greater detail in section 3 of this appendix where the use of stabilizing mechanisms is discussed.

2.2 Agricultural submodel

This submodel comprises four behavioural equations dealing with allocation of land to specific activities. The function for explaining land allocation to rice and soya crops presented problems of residual autocorrelation that required re-estimation by means of the Box and Jenkins method. Due to the fact that such a technique does not provide measures of the standard errors of parameters estimates, sensitivity analysis was carried out on a version of the agricultural submodel that included the original function for land devoted to rice and soya crops. This procedure is justified because the re-estimated function contains

TABLE III .4

OGRAPHIC AND EMPLOYMENT SUBMODEL. DEVIATIONS WITH REGARD THE BASE RUN DERIVED FROM CHANGES OF EXOGENOUS VARIABLES (PERCENTAGES)

CHANGES OF VARIABLES (*)	YEAR OF SIMULATION	TOTAL POPULATION	ACTIVE AGE POPULATION	RURAL POPULATION
BASE RUN		0	0	0
Fertility rates increased	1985	+ 2.54	+ 0.25	0
	1990	+ 3.52	+ 0.75	0
Fertility rates decreased	1985	- 2.53	- 0.24	0
	1990	- 3.50	- 0.75	0
Survival rates increased	1985	+ 0.85	+ 0.49	0
	1990	+ 1.15	+ 0.72	0
Survival rates decreased	1985	- 0.82	- 0.49	0
	1990	- 1.11	- 0.71	0
Employment growth-rate increased	1985	+ 13.01	+ 12.70	0
	1990	+ 17.23	+ 16.98	0
Employment growth-rate decreased	1985	- 11.65	- 11.41	0
	1990	- 14.86	- 14.69	0
Primary employment/total employment ratio increased	1985	0	0	+ 11.27
	1990	0	0	+ 11.27
Primary employment/total employment ratio decreased	1985	0	0	- 18.50
	1990	0	0	- 11.13

(*) All changes of variables were equal to 10% of the values utilized in the base run a large number of parameters and therefore individual effects of such parameters on the model's forecasts become smaller . Also the original function provides a better framework to assess the impact of policy variables than the re-estimated one.

The structure of the agricultural submodel means that the behavioural functions of land devoted to crops and pastures (expansion of agricultural frontier) and the coefficient for distributing this area between programme-areas do not affect the level of activity of agriculture. In fact, these functions determine the amount of land each programme-area utilizes for agriculture and cattle-raising. Since the area devoted to each crop is determined separately, any variation of these functions forecasts (due to parameter changes) will affect exclusively the area devoted to pastures which is obtained as the difference between total utilized land and that allocated to crops.

The behavioural function for land devoted to crops and pastures produces forecasts for the whole region which are disagreggated for subregions by means of the coefficient estimated by the other behavioural function. Thus if sensivity analysis is carried out at the programme-area level parameter changes of the second function are expected to present a greater impact on subregional forecasts. This is confirmed by table III.5 where parameters j,k and l are sensibly greater than g,h, and i .

From the six parameters comprised by these functions, l and h register the highest elasticity coefficients (2,31 and 1,06 respectively). Since both parameters are multiplied by variables representing the road network, sensitivity analysis confirms the initial hypothesis that the road network constitute the most significant explanatory variable of the evolution of agricultural frontier. Therefore decisions regarding its improvement or expansion constitute a powerful policy variable for controlling this process.

TABLE III.5

AGRICULTURAL SUBMODEL. SENSITIVITY ANALYSES OF CHANGING PARAMETERS OF BEHAVIOURAL FUNCTIONS

ıavioural Functions

ɹand devoted to rice and soya

IA(1,T) = -a + b* HA(1, T-1) + c* PREC(T-1) + d* CRAP (T)

ɹand devoted to other crops

IA(4,A,T) = e + f* POPR(A,T-1)

ɹand devoted to crops and pastures

;APP(T) = -g + h* REDV(T) + i* CRAP(T)

:oefficient for distributing SAPP(T) between programme-areas

:DIST(A,T) = -j + k* POP(A,T) + l* REDV(A,T)

-AMETER ANGE(*)	PERCENT COMPARISON OF PROJECTIONS WITH BASE RUN							
	Land devoted to crops and pastures		Land devoted to crops		Agricultural Employment		Value of Agricultural production	
	1985	1990	1985	1990	1985	1990	1985	1990
E RUN	0	0	0	0	0	0	0	0
.e	0	0	- 6.01	- 4.89	- 5.71	- 4.67	- 4.94	- 4.15
.e	0	0	+ 6.01	+ 4.89	+ 5.71	+ 4.67	+ 4.91	+ 4.12
.e	0	0	+ 232.38	+ 489.91	+ 220.48	+ 468.00	+ 190.68	+414.79
.e	0	0	- 33.55	- 36.60	- 31.83	- 34.97	- 27.54	- 31.00
.e	0	0	+ 24.71	+ 23.03	+ 23.44	+ 22.00	+ 20.27	+ 19.50
.e	0	0	- 22.06	- 22.37	- 20.93	- 21.37	- 18.11	- 18.94
.e	0	0	+ 15.88	+ 15.90	+ 15.07	+ 15.19	+ 13.02	+ 13.45
.e	0	0	- 15.71	- 17.89	- 14.90	- 17.09	- 12.90	- 15.15
.e	0	0	+ 3.97	+ 3.04	+ 3.57	+ 2.76	+ 5.77	+ 4.82
.e	0	0	- 3.97	- 3.04	- 3.58	- 2.76	- 5.80	- 4.82
.e	0	0	+ 1.74	+ 1.35	+ 1.57	+ 1.22	+ 2.51	+ 2.13
.e	0	0	- 1.74	- 1.35	- 1.58	- 1.22	- 2.54	- 2.13
.e	- 11.33	- 9.92	0	0	0	0	0	0
.e	+ 11.33	+ 9.92	0	0	0	0	0	0
.e	+ 18.98	+ 18.05	0	0	0	0	0	0
.e	- 18.98	- 18.05	0	0	0	0	0	0
.e	+ 4.21	+ 4.53	0	0	0	0	0	0
.e	- 4.21	- 4.53	0	0	0	0	0	0
.e	- 36.38	- 43.77	0	0	0	0	0	0
.e	+ 36.38	+ 43.77	0	0	0	0	0	0
.e	+ 24.19	+ 57.95	0	0	0	0	0	0
.e	- 18.29	- 9.05	0	0	0	0	0	0
.e	+ 35.98	+ 67.48	0	0	0	0	0	0
.e	- 35.77	- 18.58	0	0	0	0	0	0

(*) All parameter changes were equal to one standard error of estimate of the parameter involved.

For assessing the results of the sensitivity analysis carried out on explanatory functions on land allocated to rice and soya and to other crops (subsistence farming) it is necessary to bear in mind that the submodel utilizes land devoted to each crop as the basic element for determining the level of activity of the agricultural sector. In fact, once land allocation is determined, total employment and value of production are obtained by applying exogenously specified coefficients to the area devoted to each crop. It follows that sensitivity of parameters measured in terms of employment or value of production will lead to similar conclusions than if measured in terms of land devoted to crops.

Parameter changes of the behavioural function for land devoted to other crops do not present a significant impact on the level of activity of agriculture at the programme-area level (elasticity coefficients being 0.03 for e and 0.07 for f) . This is due to the fact that subsistence crops occupy a very small proportion of agricultural land, although intensively utilized. This higher intensity of land use entailed by subsistence farming explains that the effects of parameter changes induce a greater change of value of production than of the cultivated area.

The equation used for explaining the evolution of land devoted to rice and soya, for its part, is the one that most decisively affects the level of activity of subregional agriculture since these crops represent more than 80% of the area under cultivation.

From table III. 5 it can be deduced that the most critical parameter of this submodel is b which in a 15 year forecast induces a percent deviation of land devoted to crops eleven times greater than the initial positive change of parameter. The reason for such an extraordinary impact derives from the fact that the behavioural function contains a lagged dependent variable in its left hand side, thus it reproduces with multiplier effects along the whole forecasting period any deviation derived from changes of parameters. This amplifier effect is greater than that observed in the demographic submodel because the numbers involved are bigger (in this case forecasts are of the order of 200 000 hectares while the demographic submodel was projecting percent rates) and also because the standard error of parameter b is significantly bigger than those of net migration functions.

This situation makes the behavioural equation for land allocated to rice and soya a critical element for the stability of the agricultural submodel.

Fortunately, the ecological constraint on agricultural land constitutes an effective balancing mechanism. In fact, as can be seen in table III.6, such a constraint restores equilibrium by eliminating all positive deviations and reducing the negative ones. Since it operates exclusively on land devoted to crops its most notorious effect is observed in forecasts of that variable, but it is equally effective in forecasts of employment and value of production.

Fig. III.2 presents the way in which the ecological constraint modifies forecasts of a normal run of the agricultural submodel. In 1988 the projected area for crops exceeds the ecological limit in the programme-area of Alto Taquari, thus the model assumes that the total area cultivated from the year 1988 onwards equals land available for agriculture. For disaggregating this area between the four selected crops it is further assumed that projected land for coffee and sugar cane plantations is not affected by the ecological constraint, thus all adjustments are made on the area devoted to subsistence farming and rice and soya crops. Once land allocation is redefined the model determines agricultural employment and value of production using the normal procedure.

TABLE III.6

'FECTS OF THE ECOLOGICAL CONSTRAINT ON THE RESULTS OF THE AGRICULTURAL 'BMODEL. DEVIATIONS WITH REGARD THE BASE RUN DERIVED FROM CHANGES OF PARAMETERS .YEAR 1990

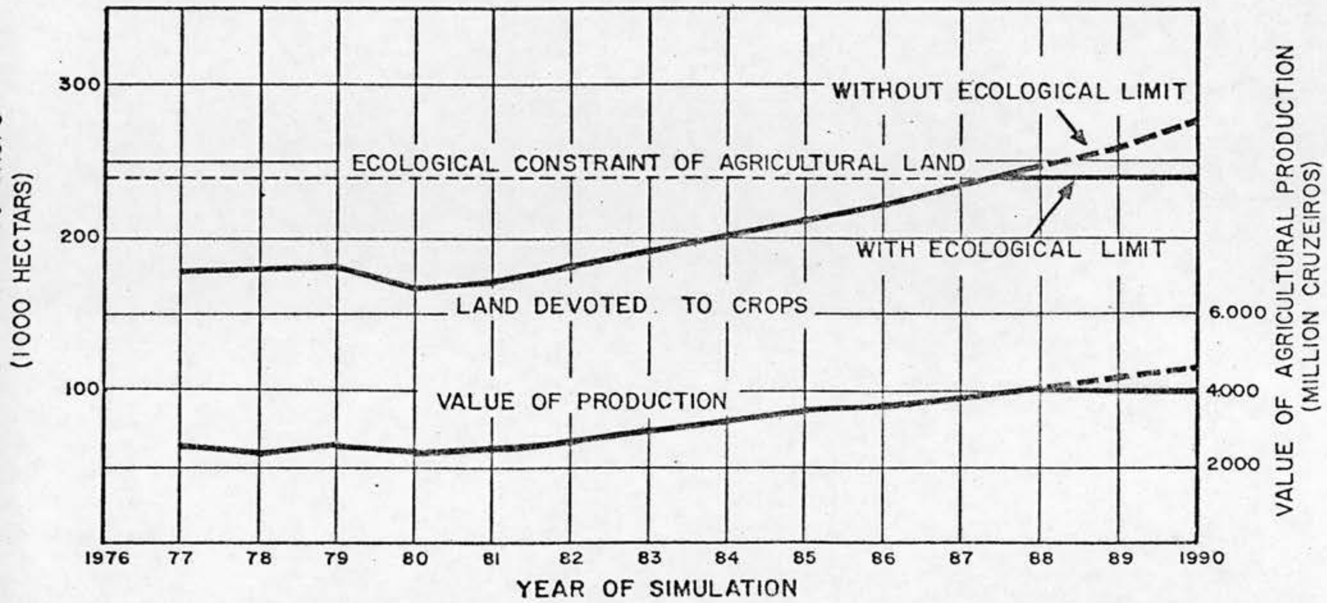
(PERCENTAGES)

PARAMETER CHANGES (*)	LAND DEVOTED TO CROPS		AGRICULTURAL EMPLOYMENT		VALUE OF AGRIC.PRODUCTION	
	Without limit	with limit	without limit	with limit	without limit	with limit
a + s.e	- 4.89	0	- 4.67	- 0.04	- 4.15	+ 0.55
a - s.e	+ 4.89	0	+ 4.67	+ 0.04	+ 4.12	- 0.04
b + s.e	+ 489.91	0	+ 468.00	+ 0.11	+ 414.79	- 1.77
b - s.e	- 36.60	- 28.73	- 34.97	- 18.58	- 31.00	- 15.34
c + s.e	+ 23.03	0	+ 22.00	+ 0.04	+ 19.50	- 0.05
c - s.e	- 22.37	- 12.72	- 21.37	- 0.04	- 19.84	+ 0.60
d + s.e	+ 15.90	0	+ 15.19	+ 0.04	+ 13.45	- 0.05
d - s.e	- 17.89	0	- 17.09	- 0.04	+ 15.15	+ 0.52
e + s.e	+ 3.04	0	+ 2.76	- 0.12	+ 4.82	+ 1.95
e - s.e	- 3.04	0	- 2.76	+ 0.13	- 4.82	- 2.02
f + s.e	+ 1.35	0	- 1.22	- 0.05	+ 2.13	+ 0.87
f - s.e	- 1.35	0	- 1.22	+ 0.06	- 2.13	- 0.87

(*) All parameters changes were equal to one standard error of estimate of the parameter involved.

FIG. III.2

EFFECTS OF THE ECOLOGICAL CONSTRAINT ON THE OUTPUT OF THE AGRICULTURAL SUBMODEL. PROGRAMME AREA OF ALTO TAQUARI



With regard to the sensitivity of the model to changes of exogenous and policy variables no significant problems were detected. As shown by table III.7 the model is more sensitive to changes of prices than to variations in the amount of credit granted to agriculture. This means that, if the model is accepted as a valid representation of the regional system, price policies constitute a more effective tool than credit policies for orientating the behaviour of agriculture. In fact, the impact of prices on land under cultivation is almost double that of credit. If analysis is performed taking the value of production this situation becomes more evident. In order to make comparisons possible table III.7 only takes into account the effects of prices as policy variables excluding their effects on the valorization of physical production. If this effect is considered, a 10% increase in agricultural prices would generate a 17.62% rise in the value of agricultural production instead of the 6.93% reported in table III.7.

TABLE III.7

:ICULTURAL SUBMODEL. DEVIATIONS WITH REGARD THE BASE RUN DERIVED FROM CHANGES OF POLICY VARIABLES AND EXOGENOUS VARIABLES

(PERCENTAGES)

HANGES OF VARIABLES (*)	YEAR OF SIMULATION	LAND DEVOTED TO CROPS	AGRICULTURAL EMPLOYMENT	VALUE OF AGRICULTURAL PRODUCTION
ASE RUN		0	0	0
rice of rice in-reased	1985 1990	+ 7.57 + 8.20	+ 7.17 + 7.83	+ 6.45 + 6.93
rice of rice re-uced	1985 1990	- 6.60 - 7.96	- 6.27 - 7.60	- 5.64 - 6.75
redits for agricul-ure increased	1985 1990	+ 3.72 + 4.34	+ 3.52 + 4.15	+ 3.16 + 3.65
redits for agricul-ure reduced	1985 1990	- 3.02 - 4.17	- 2.88 - 3.98	- 2.58 - 3.54
ural population in-reased	1985 1990	+ 0.96 + 0.75	+ 0.86 + 0.68	+ 1.13 + 1.19
ural population re-uced	1985 1990	- 0.96 - 0.75	- 0.87 - 0.68	- 1.16 - 1.19
and productivity for ice and soja increased	1985 1990	0 0	0 0	+ 6.86 + 7.13
and productivity for ice and soja reduced	1985 1990	0 0	0 0	- 6.90 - 7.15
and productivity for offee increased	1985 1990	0 0	0 0	+ 0.48 + 0.34
and productivity for offe reduced	1985 1990	0 0	0 0	- 0.48 - 0.34
and productivity for ugar increased	1985 1990	0 0	0 0	+ 1.00 + 0.81
and productivity for ugar reduced	1985 1990	0 0	0 0	- 1.03 - 0.83
and productivity for ther crops increased	1985 1990	0 0	0 0	+ 1.58 + 1.52
and productivity for ther crops reduced	1985 1990	0 0	0 0	- 1.64 - 1.68

All changes of variables were equal to 10% of the values utilized in the base run. No ecological constraint was included in the simulations

Rural population, a variable transferred from the demographic submodel for explaining the evolution of subsistence farming, has no significant impact on the level of agricultural activity because of the small area devoted to these crops. Finally, changes in land productivity only affect the value of production and their impact is proportional to the relative importance of each crop.

2.3 Cattle-raising submodel

This submodel comprises three behavioural functions, one for explaining the transfers of cattle between programme - areas and two referinq to extraction rates. These two last equations presented problems of residual autocorrelation and were re-estimated by means of the Box and Jenkins method. For similar reasons as in the agricultural submodel, sensitivity analysis was carried out on a version of the cattle-raising submodel that included the original functions of extration rates.

This submodel utilizes lagged endogenous variables both for projecting the stock of cattle and for determining extraction rates, therefore, it tends to amplify the effects of any deviation along the whole forecasting period. However, contrary to expectations the cattle raising submodel presents a reasonable level of stability with regard to changes of parameters (See table III.8).

In fact, even the equation for explaining transfers of cattle that is an exponential function does not generate big deviations because the exponential term is dividing a fixed parameter. In this way despite parameter b being the most sensitive of the whole submodel its elasticity coefficient reaches 1.14 in a fifteen year forecast. This is to be regarded as very good for a function of this type.

From another point of view, cattle stock forecasts are far more sensitive to changes of parameters in the function of extraction rates for cows than in that for male cattle. This is natural since a change in the number of cows directly affects the reproductive capacity of the overall herd.

TABLE III.8

TLE RAISING SUBMODEL. SENSITIVITY ANALYSES OF CHANGING PARAMETERS OF BEHAVIOURAL FUNCTIONS

EHAVIOURAL FUNCTIONS

RANSFER COEFICIENT

RANSF (A,T) = a / (ANPP(A,T-1)^{b}

XTRACTION RATES

EXT(3,1,T) = c + d*PEXT(3,1,T-1) - e* PEXT(3,1,T-2) - f* PREC(T+1) + g* CRPE(T-1) - (Bulls and oxens)

EXT(3,2,T) = h + i* PEXT(3,2,T-1) - j* PEXT(3,2,T-2) - k* PREC(T-1) + 1* CRPC(T-1) - (Cows)

AMETER CHANGE (*)	PERCENT COMPARISON OF PROJECTIONS WITH BASE RUN					
	CATTLE STOCK		% OF COWS		VALUE OF PRODUCTION	
	1985	1990	1985	1990	1985	1990
BASE RUN	0	0	0	0	0	0
a + s.e	+ 15.23	+ 23.87	+ 0.61	+ 0.60	+ 13.54	+ 21.99
a - s.e	- 13.26	- 19.34	- 0.61	- 0.62	- 12.08	- 18.27
b + s.e	- 15.12	- 21.93	- 0.72	- 0.71	- 13.87	- 20.70
b - s.e	+ 17.97	+ 28.35	+ 0.69	+ 0.71	+ 16.03	+ 26.14
c + s.e	- 3.53	- 3.33	+ 3.65	+ 3.43	+ 0.91	+ 0.85
c - s.e	+ 5.16	+ 5.04	- 4.91	- 4.81	- 1.29	- 1.25
d + s.e	- 2.76	- 2.82	+ 2.82	+ 2.90	+ 0.73	+ 0.71
d - s.e	+ 2.33	+ 2.52	- 2.29	- 2.45	- 0,57	- 0.62
e + s.e	+ 2.29	+ 2.35	- 2.24	- 2.30	- 0.52	- 0.60
e - s.e	- 2.68	- 2.62	+ 2.76	+ 2.68	+ 0.75	+ 0.64
f + s.e	+ 5.54	+ 5.74	- 5.24	- 5.43	- 1.35	- 1.40
f - s.e	- 3.77	- 3.66	+ 3.90	+ 3.79	+ 0.99	+ 0.89
g + s.e	- 1.21	- 1.41	+ 1.21	+ 1.42	+ 0.34	+ 0.35
g - s.e	+ 1.35	+ 1.62	- 1.34	- 1.59	- 0.32	- 0.41
h + s.e	- 20.33	- 29.53	- 3.65	- 3.57	- 18.91	- 28.13
h - s.e	+ 25.53	+ 31.83	+ 3.50	+ 1.53	+ 23.26	+ 31.47
i + s.e	- 17.68	- 25.24	- 3.12	- 2.86	- 15.94	- 23.93
i - s.e	+ 11.58	+ 17.61	+ 1.46	+ 1.46	+ 10.81	+ 16.68
j + s.e	+ 12.66	+ 19.00	+ 1.79	+ 1.68	+ 11.43	+ 17.58
j - s.e	- 18.30	- 26.46	- 3.29	- 3.08	- 16.85	- 25.15
k + s.e	+ 16.45	+ 28.57	+ 2.64	+ 2.83	+ 14.67	+ 26.32
k - s.e	- 14.72	- 23.16	- 3.05	- 3.08	- 13.26	- 21.72
l + s.e	- 3.80	- 6.68	- 0.74	- 0.95	- 3.31	- 6.13
l - s.e	+ 3.95	+ 7.17	+ 0.72	+ 0.93	+ 3.67	+ 6.56

(*) All parameter changes were equal to one standard error of estimate of the parameter involved.

The submodel also presents a low sensitivity to changes in policy variables. Table III.9 shows that a 10% increase in beef prices lead to a 6.61% increase of cattle stock in a fifteen year projection while for a similar change in the amount of credit granted to this activity total stock is reduced by 1.99% in the same period . More important than the magnitude of the effects of these variations are policy implications derived from cause-effects relationships. In fact, due to the signs of the coefficients of these variables in the behavioural function a positive change in beef prices reduces extraction rates and therefore the final effect is an increase in the cattle stock. Credits, for its part, behaves in the opposite direction, thus a rise in the amount of loans lead to a reduction of both cattle stock and value of production.

Price behaviour is consistent with the cattle cycle described in chapter 4, but the effects of credit changes are in conflict with theoretical considerations. On studying this situation it was found that credit granted to cattle raising is normally utilized for increasing the level of activity of cattle farms and for improving the genetic quality of the herd. Traditionally these objectives are achieved by purchasing high quality reproducers, improving sanitary controls and by increasing and improving pastures. All these betterments lead to a higher capacity of farms to support cattle and consequently to a greater stock of animals of an improved average quality which, in its turn, enables a higher rate of extraction. Since some of the variables affected by credit granted to this activity (natality rates, survival rates and average weight) are defined exogenously and were kept constant in the simulations performed for testing the submodel's sensitivity to changes of credits, the outcome of such tests constitutes a partial assessment of the effects of this policy variable. Therefore, the present version of the submodel does not allow a proper evaluation of the impact of credit on the behaviour of cattle-raising since for that purpose the relationships between this variable and natality rates, survival rates and average weight of cattle must be defined and quantified. However, different

TABLE III . 9

CATTLE RAISING SUBMODEL. DEVIATIONS WITH REGARD THE BASE RUN DERIVED FROM CHANGES OF POLICY VARIABLES AND EXOGENOUS VARIABLES (PERCENTAGES)

CHANGES OF VARIABLES (*)	YEAR OF SIMULATION	CATTLE STOCK	% OF COWS	VALUE OF PRODUCTION
BASE RUN		0	0	0
Price of beef increased	1985	+ 4.38	- 0.45	+ 2.74
	1990	+ 6.61	- 0.44	+ 4.94
Price of beef decreased	1985	- 4.16	+ 0.40	- 2.73
	1990	- 6.16	+ 0.38	- 4.64
Credit for cattle raising increased	1985	- 1.37	+ 0.62	- 0.28
	1990	- 1.99	+ 0.73	- 0,74
Credit for cattle raising decreased	1985	+ 1.43	- 0.67	+ 0.57
	1990	+ 2.09	- 0.78	+ 0.84
Natality rate increased	1985	+ 14.52	- 3.50	+ 19.55
	1990	+ 21.54	- 3.52	+ 26.74
Natality rate decreased	1985	- 13.36	+ 3.92	- 17.37
	1990	- 18.63	+ 3.96	- 22.37
Survival rate increased	1985	+ 1.66	+ 0.38	+ 2.67
	1990	+ 2.33	+ 0.37	+ 3.31
Survival rate decreased	1985	- 8.24	- 0.80	- 11.55
	1990	- 12.39	- 0.80	- 15.45
Average weight increased	1985	0	0	+ 10.12
	1990	0	0	+ 10.09
Average weight decreased	1985	0	0	- 9.83
	1990	0	0	- 10.00
Animal/pasture ratio increased	1985	- 9.45	- 0.43	- 8.49
	1990	- 13.92	- 0.44	- 13.05
Animal/pasture ratio decreased	1985	+ 11.61	+ 0.47	+ 10.41
	1990	+ 18.05	+ 0.47	+ 16.72

(*) All changes of variables were equal to 10% of the values utilized in the base run hypotheses of such relationships can be tested by simulating the model for various sets of values for the above mentioned variables.

The submodel's sensitivity to changes of exogenous variables is relatively high. A 10% increase in natality rate lead to a 21.54% of rise of total cattle in 1990 and a 26.54% increase in sectorial product. This means elasticity coefficients of 2.15 and 2.65 respectively. The reasons for such a significant impact deal with the accumulative effects of the cohort survival mechanism utilized for projecting the stock of cattle.

The structure of the behavioural function for cattle transfer coefficient, for its part, means that variations of the animal/pasture ratio induce inverse changes on output variables. Thus, elasticity coefficients for negative changes of the variable reach - 1.81 in 1990 if measured in terms of cattle stock and - 1.67 if refering to the value of production.

Finally, although the submodel is sensitive to changes of exogenous variables its overall stability is not seriously affected since the ecological constraint on the animal support capacity of each programme-area prevents significant distortions with respect to the base run, especially in programme areas of high density of cattle.

2.4 INDUSTRIAL AND TERTIARY SECTORS SUBMODELS

These submodels comprise five behavioural functions, but only three were estimated by standard econometric techniques. The other two constitute mere hypotheses that could not be properly tested because of lack of information. Thus sensitivity analysis of these submodels refers exclusively to the behavioural functions of the timber industry, diverse industries and to commerce and services.

As shown by Table III.10 the behavioural function of diverse industries is that which presents the greatest impact on aggregate

TABLE III.10

INDUSTRIAL AND TERTIARY SECTORS SUBMODELS.SENSITIVITY ANALYSES OF CHANGING PARAMETERS OF BEHAVIOURAL FUNCTIONS

Behavioural Functions:

Added value of timber industry - $VAMAD(A,T) = -a + b^{*}\,DESMAT(A,T)$

Employment in diverse industries - $EMIOU(A,T) = c^{*}(POPU(A,T-1))^{d}$

Employment in commerce and services - $EMCSE(A,T) = -e + f^{*}POPU(A,T-1)$

PARAMETER CHANGE (*)	PERCENT COMPARISON OF PROJECTIONS WITH BASE RUN			
	Secondary and tertiary product		Secondary and tertiary employment	
	1985	1990	1985	1990
BASE RUN	0	0	0	0
a+s.e	- 0.32	0 (**)	- 0.37	0 (**)
a-s.e	+ 0.32	0 (**)	+ 0.37	0 (**)
b+s.e	+ 1.69	0 (**)	+ 0.20	0 (**)
b-s.e	- 1.69	0 (**)	- 0.20	0 (**)
c+s.e	- 4.31	- 4.35	- 3.28	- 3.38
c-s.e	+ 11.22	+ 11.33	+ 8.53	+ 8.80
d+s.e	+ 12.82	+ 13.49	+ 9.76	+ 10.48
d-s.e	- 4.56	- 4.67	- 3.47	- 3.63
e+s.e	- 0.65	- 0.50	- 0.72	- 0.54
e-s.e	+ 0.65	+ 0.50	+ 0.72	+ 0.54
f+s.e	+ 1.99	+ 2.06	+ 2.19	+ 2.23
f-s.e	- 1.99	- 2.06	- 2.19	- 2.23

(*) All parameter changes were equal to one standard error of estimate of the parameter involved

(**) Constrained by the lower limit of activity established for the timber industry results. This is explained by the exponential character of such equations and obviously parameter d that constitutes the exponent of urban population is the most sensitive. A positive change of one standard error of this parameter induces in fifteen years an increase of 10.48% of total employment and 13.49 of added value generated by industrial and tertiary activities. This means elasticity coefficients of 1.22 and 1.57 respectively.

Parameter c is the antilogarithm of a negative mumber, thus although it has a positive sign it varies inversely with changes in the absolute value of the logarithm. For this reason the effects of parameter c present a negative sign for positive changes and positive sign in the opposite situation.

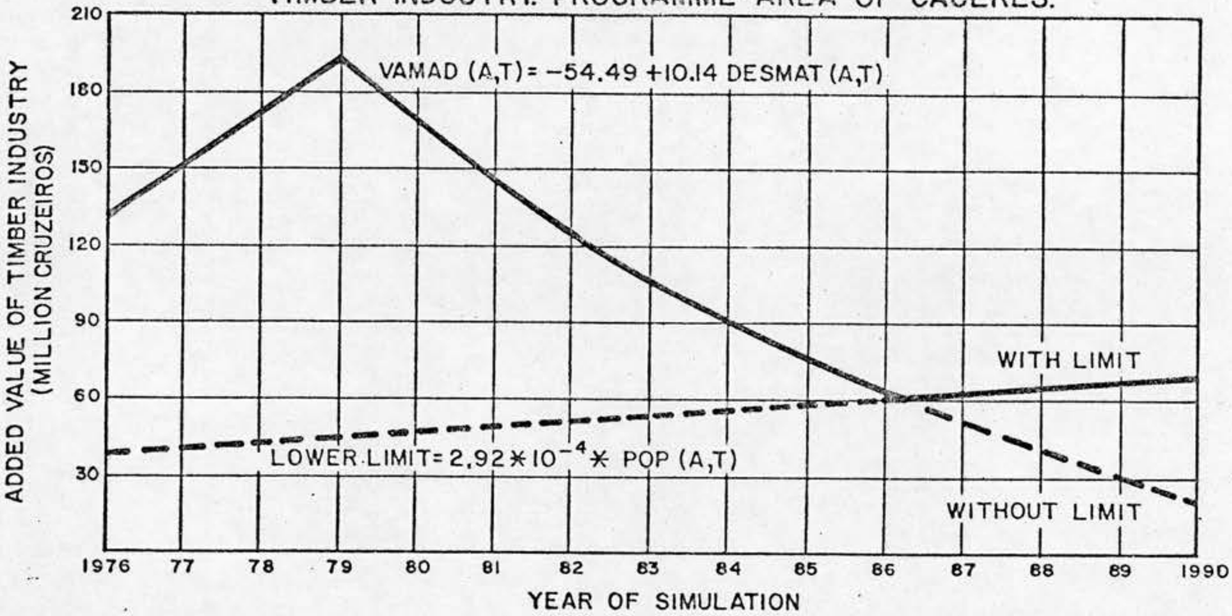
The behavioural function of timber industry presents a very small impact on aggregate results for 1985 and in 1990 it is constrained by the lower limit established for this activity. As explained in chapter 4 the industrial sector of the model explains the level of activity of the timber industry as a function of the amount of land deforested the previous year due to the expansion of the agricultural frontier. Although this consitutes a reasonable explanation for the average behaviour of this branch of regional industry, it greatly underestimated its level of activity in dense areas where all available land was incorporated into agriculture and cattle raising.

When deforestation comes to an end, production in the timber industry decreases but simultaneously a change in the type of production is observed. In fact, while in the early stages of land occupation the timber industry is mainly engaged in primary transformation of native wood, at higher levels of population density, production tends to orientate to intermediate and final goods for local markets.

Since this behavioural equation does not consider such a process, the model reproduces the decline of production of saw-mills but c mits the increase of production of other industries that process timber. In order to correct this problem an explicit lower limit was established for the added value of the timber industry. This constraint was defined as the added value per capita of the timber industry at the national level multiplied by the population of each programme-area and its effects on the submodel's forecast are graphically explained in Fig. III.3.

FIG. III. 3

EFFECTS OF THE CONSTRAINT ON THE LEVEL OF ACTIVITY OF THE TIMBER INDUSTRY. PROGRAMME-AREA OF CACERES.



The sensitivity of these submodels to changes of exogenous and policy variables is very small. In fact, as shown in table III.11 the effects of a 10% change on the rate of growth of export industries are almost nil while the same change in the rate of growth of mining lead to variations of around 1% of aggregate employment in a 15 year simulation. The effects of changes in the deforested area are also insignificant. Changes in urban population however induce important variations in aggregate results. Since it is reasonable to assume that changes in urban population derive from variations of total population rather than from short term changes in the proportion of urban-rural populations, sensitivity analysis was carried out for a joint 10% variation of total and urban populations.

TABLE III.11

INDUSTRIAL AND TERTIARY SECTORS SUBMODELS. DEVIATIONS WITH REGARD THE BASE RUN DERIVED FROM CHANGES OF POLICY VARIABLES AND EXOGENOUS VARIABLES

(PERCENTAGES)

CHANGES OF VARIABLES (*)	YEAR OF SIMULATION	SECONDARY AND TERTIARY ACTIVITIES	
		PRODUCT	EMPLOYMENT
ASE RUN		0	0
orested area increased	1985	+ 0.35	+ 0.41
	1990	0	0
orested area decreased	1985	- 0.35	- 0.41
	1990	0	0
ulation (**) increased	1985	+ 8.22	+ 7.83
	1990	+ 8.39	+ 7.88
ulation (**) decreased	1985	- 8.21	- 7.82
	1990	- 8.38	- 7.89
e of growth of mining increas	1985	+ 0.32	+ 0.47
	1990	+ 0.71	+ 1.05
e of growth of mining descreas	1985	- 0.29	- 0.42
	1990	- 0.59	- 0.88
e of growth of export indus-es increased	1985	(x)	(x)
	1990	(x)	(x)
e of growth of export indus-es decreased	1985	(x)	(x)
	1990	(x)	(x)

All changes of variables were equal to 10% of the values utilized in the base run

) Includes a 10% change of both urban and total populations

smaller than 0.01

In this way three effects were considered simultaneously . They are the variation of the minimum level of activity of the timber industry derived from changes of total population and variations of employment generated by diverse industries and commerce and services due to changes of urban population. The joint effects of a 10% increase of both variables induce a 7.88% rise in aggregate employment and 8.39 of added value in 1990.

Due to the fact that the industrial and tertiary activities sub models do not contain interr elationships linking sectorial projections (except aggregation of sectorial results), the effects of each equation on aggregate results are proportio - nal to the relative importance of each sector. The commerce and services sector is by far the most important activity included in these submodels representing more than 70% of employment and more than 64% of added value generated by industrial and tertiary activities in the programme area of Cace - res, which was utilized for testing the sensitivity of these submodels. Therefore it is expected that the effects of changes of the exogenous variable operating through the behavioural e quation of commerce and service (POPU) will be the most signifi - cant for aggregate results. Two special simulations carried out for quantifying the impact on aggregate results derived from changes of urban population operating exclusively through the commerce and services sector confirm this expectancy. They show that a 10% increase of POPU leads to a 7.31% increase of total employment and 6.83 of aggregate product. This means that the effects generated through commerce and services represent 92.8% of the total variation of employment induced by changes of urban and total populations and 81.4% of their impact on added value.

3. TRANSFERS OF VARIABLES BETWEEN TIME PERIODS AND BETWEEN SUB MODELS

As said above, transfers of variables between submodels and time periods make the model cybernetic. This is to say, such interr elationships constitute the way in which the model reproduces dynamic characteristics of the regional socio - econo mic system. Therefore monitoring the algorithm that regulates these transfers is a crucial part of the whole modelling process since this element makes the composite model different from a purely additive structure of partial equations.

Transfers of variables between time periods constitute mainly a source of instability for the model's forecasts. Secondarily such transfers hindered the formulation of the computer programme. In fact, the use of lagged endogenous variables made it necessary to define a large number of store variables and also required special instructions for controlling the iterations of specific subroutines. These iterations and storing operations greatly increased processing time since, because of lack of programming expertise, a general purpose computer language (extended FORTRAN IV) was utilized instead of a special simulation language.

More important than programming implications are the accumulative effects that the use of lagged endogenous variables produce in the model's results. As reported in section 2 of this appendix these effects are particularly important in the demographic , agricultural and cattle-raising submodels. For reducing this type of deviations in the model's output, special ecological constraints and limiting functions were defined.

The effectiveness of such balancing mechanisms was discussed in preceding section, thus no further comments on this aspect seem necessary.

Transfers of variables between submodels, for their part , were responsible for unstable and sometimes unrealistic results obtained in the first few runs of the model. In fact , initial simulations generated some strange results that were in conflict with theoretical considerations. For example, unemployment rates became negative, population growth in certain programme-areas was highly unstable, after the fourth year of simulation production of timber industries became negative , evolution of cattle stock in some programme areas presented cyclical behaviour, etc.

After studying these problems it was concluded that they were the consequence of critical values of variables generated in other submodels and then used in behavioural equations for forecasting purposes. In order to correct such deviations it was necessary to establish constraints either to the functions that utilize the transferred variable or to the value the variable may adopt . The most critical transferred variables are the rate of growth of total employment, deforested area and the cattle pastures ratio. Let us see the main effects generated by these variables and the solutions provided for them.

As mentioned earlier, the most important source of instability of the whole model derived from rates of growth of total employment utilized for quantifying net migration rates. Rates of growth of total employment are generated by the composite model by dividing the current total employment of each programme area with that generated the previous year, and then fed into the demographic submodel for simulating the population of next year. Besides the high sensitivity of the demographic submodel to changes of this variable (see section 2.1 above), its critical character derives from the fact that rates of growth of total employment are, in their turn, highly sensitive to the effects of some policy variables, especially in programme areas with low levels of economic activity. Perhaps the best way to illustrate the effects of the interrelationships taking place between submodels is to use a practical example. Let us take the case of the programme area of Alto Paraguay, this, in 1980 had a population of around 92,000 inhabitants and provided employment for nearly 19,500 persons. Between 1975 and 1980 population grew at a rate of 5.2% per annum while employment registered an average rate of growth of 3.9% per year.

Let us assume that during 1981 and 1982 a special programme of public works involving a total expediture of 900 million cruzeiros is implemented in the area(*). Such a project

(*) Estimated cost of improving 280 km of roads. In order to make the problem easier the impact of increasing the road network on agricultural production is neglected.

will generate 1660 new jobs in civil construction for a two year period. The initial effect of this programme of public works will be a rise in the rate of growth of total employment (CREMP) in 1981 from 6.26% to 14.77%. Simultaneously, since the model considers employment in civil construction as urban employment, the primary employment/total employment ratio (PEP) falls from 57.71 in 1980 to 53.17 in 1981 reducing the rural population coefficient from 54.08% in 1980 to 49.34% in 1981.

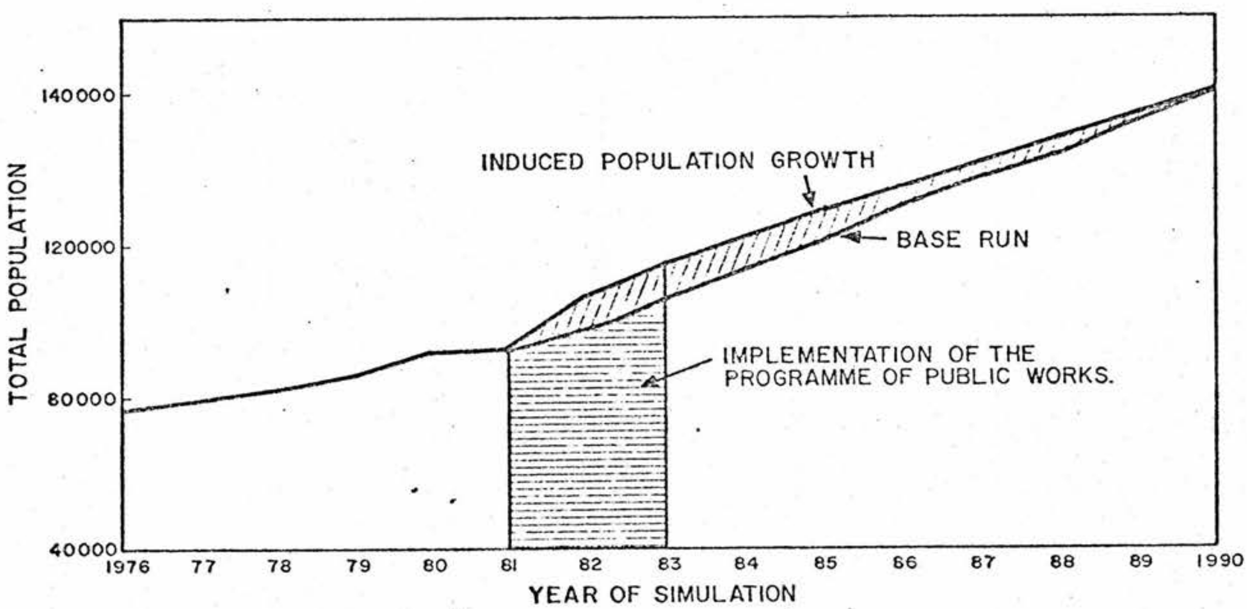
These variables are fed into the demographic submodel for estimating the population of 1982. This, on the one hand, leads to a rate of growth of total population of 14,26% instead of the 6.6% estimated under normal conditions. On the other hand, the new value of PEP induces an extraordinary growth of urban population (26% between 1981 and 1982) which becomes greater than rural population. Because of the one year lag relationships included in all behavioural equations that utilize demographic variables as explanatory ones , this abnormal growth of total and urban population does not affect the level of economic activity in 1982, its effects are manifested from 1983 onwards.

During 1982, however the greater employment induced by the programme of public works will be maintained but its effects on the rate of growth of total employment will be severely reduced since such a rate is determined by comparing the total employment of 1982 with that of 1981. In fact the new CREMP will be 7.4%, instead of the 8.0% expected without the special investment programme. Consequently total population growth between 1982 and 1983 becomes higher under normal conditions (8.2%) than with the effects of the project (7.6%).

As mentioned , during 1983 the induced population growth of the preceding year generates an increased level of activity (and of employment) in commerce and services, diverse industries and in subsistence farming. This greater employment compensates the depressive effects derived from the end of the pro gramme of public works, leading to a CREMP in 1983 of 4.88%, which also is lower than that forecasted under normal conditions. This process is repeated with a decreasing intensity of the effects derived from the public works programme until 1988 when employment generated under normal conditions equals the curve of total employment influenced by such investments. From this moment onwards the effects of public investments disappear and equilibrium is restored, consequently in 1989 additional population becomes very small (See Fig. III.4 and Table III.12).

FIG. III. 4

EFFECTS OF A SPECIAL PROGRAMME OF PUBLIC WORKS ON POPULATION PROJECTIONS. PROGRAMME AREA OF ALTO PARAGUAY.



Due to the fact that the primary employment/total employment ratio is distorted by the sudden increase of urban employment it tends towards normal values as the intensity of the induced effects on urban employment decreases.

From another point of view, the time lag between the increase of total employment due to exogenous factors and its effects on population growth makes it possible for the model to produ

TABLE III.12

EFFECTS OF A SPECIAL PROGRAMME OF PUBLIC WORKS ON DEMOGRAPHIC FORECASTS. PROGRAMME AREA OF ALTO PARAGUAY

YEAR OF SIMULATION	EMPLOYMENT				TOTAL POPULATION		
	TOTAL BASE RUN	DERIVED FROM PUBLIC WORKS PROGRAMME			EXTRAPOLATION OF HISTORIAL TRENDS	'UNCONSTRAINED' SIMULATION	'CONSTRAINED SIMULATION
		GENERATED BY P.W.	INDUCED GROWTH	TOTAL			
1976	16,612			16,612	76,883	76,883	76,883
1977	17,360			17,360	79,034	79,034	79,034
1978	18,146			18,146	81,245	81,245	81,245
1979	19,390			19,390	86,984	86,984	86,984
1980	19,490			19,490	91,974	91,974	91,974
1981	20,711	1,660		22,371	95,373	93,713	95,037
1982	22,368	1,660		24,028	99,898	107,084	105,599
1983	23,610		1,588	25,198	108,053	115,253	113,655
1984	25,082		1,478	26,560	114,498	121,417	120 204
1985	26,433		1,070	27,503	122,026	128,498	127,214
1986	27,811		842	28,653	130,470	135,262	133,910
1987	29,294		272	29,566	137,821	141,624	140,208
1988	30,580		-	30,580	145,716	147,011	145,542
1989	31,497			31,497	152,828	152,902	152,552
1990	32,442			32,442	159,705	159,782	159,417

ce negative unemployment rates. In fact, let us assume that the programme area under analysis was at its full employment level in 1980. Thus the 1.9% increase of its labour force between 1980 and 1981 will be insufficient to provide the additional manpower required by the 14.77% rise in labour demand during the same period, therefore total employment (as determined by the model) will be greater than the available labour force. As the model determines unemployment rates by means of the relationship total employment rate = 1 - total employment/total labour force; if total employment is greater than the labour force such a rate becomes negative.

This example shows the magnitude of the impact on the model's results derived from a relatively small public intervention on one programme-area (*). These distortions of the model's forecasts derive from the fact that the construction of roads or other public works usually induce a disproportionate growth of total employment in the programme-areas where these investments take place. Since this is a temporary increase in employment its effect as a migration inducer is much lower than the creation of permanent jobs. Thus as the model does not discriminate permanent and temporary employment it overestimates net migration , this distortion being particularly important in programme-areas with a small population.

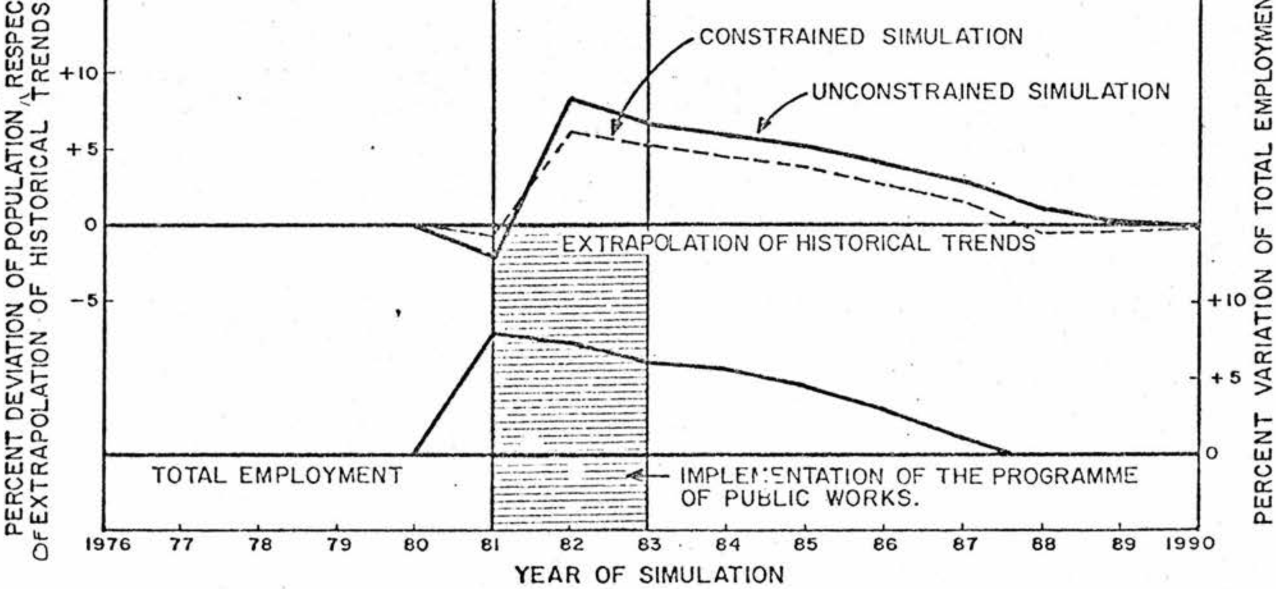
(*) It is necessary to bear in mind that these effects are the outcome of a 900 million cruzeiros investment programme during a two year period. For assessing the relative importance of such magnitude it should be compared with the development proposals formulated by EDIBAP. As can be seen in Appendix II, the regional development plan proposed by EDIBAP implies 57,701.1 million cruzeiros of investments in the whole Upper Paraguay River Basin during a five year period. This roughly means an average annual investment of 1,428 million cruzeiros per programme area, this is to say an intervention more than three times greater than that utilized in the example and affecting the regional system during a longer period.

For preventing this type of distortions special constraints were introduced in the computer programme. It was assumed that the rate of growth of total employment for a given year in any programme-area could not differ from the average rate of the last 3 years more than 30% of such average rate. In case the obtained rate exceeded such a "maximum variation range" the nearest limit was utilized. Simultaneously, no more than 1% of annual variation was allowed for the coefficient of rural population.

The effects of these constraints on the model's results are presented in Fig. III.5 and in the last column of Table III. 12 . Due to the fact that between 1979 and 1980 total employment grew at a very low rate (0.52%) the base run (unconstrained simulation) reduces the rhythm of demographic growth between 1980 and 1981. Such a sudden variation of the rate of growth of total employment induces differences between constrained and unconstrained simulations in 1981. Thus, in order to differentiate the effects of the programme of public works from those associated with the low dynamism of the subregional economy in 1979-80, simulations were compared with a demographic projection based on an extrapolation of historical trends.

FIG. III. 5

EFFECTS ON POPULATION FORECASTS DERIVED FROM CONSTRAINTS ON TOTAL EMPLOYMENT GROWTH RATES AND PRIMARY EMPLOYMENT / TOTAL EMPLOYMENT RATIOS.



As Fig. III.5 shows, the constraints introduced in the computer programme reduce the amplitude of deviations but do not impede the model from accounting for the dynamic effects of public investments (or of other policy instruments) on the regional system.

Other variables transferred between submodels that affect the stability of aggregate results are the area deforested each year and land devoted to pasture . Both variables are generated by the agricultural submodel and utilized in the industrial and cattle raising submodels respectively. Deforested area is obtained as the variation of land devoted to crops and pasture between consecutive years and utilized for determining the level of activity of timber industries.

Such a variable is quantified at the regional level as a linear function of the extension of the road network and the amount of credit granted to rural activities and then disaggregated for programme areas by means of a distribution coefficient. Land devoted to crops and pasture is constrained by an ecological limit which operates both at the regional level and for each programme area. In this way the deforested area is progressively reduced as utilized land approximates the ecological constraint and becomes 0 when such a limit is reached. Consequently the added value of timber industries decreases as the level of land occupation increases and becomes negative when the area deforested each year is smaller than 5,600 hectares

This problem is solved by the lower limit established for the level of activity of timber industries as explained in section 2.4 above.

Land devoted to pasture , for its part, is used for quantifying the cattle/pasture ratio which constitutes the independent variable of the equation that determines the coefficient of cattle transfers between programme areas. Land devoted to pasture is obtained for each programme area as the difference between total utilized land and the cultivat ed area. Projections of these variables are relatively stable and also they are limited by ecological constraints, however, cultivated area varies with changes of agricultural prices and credit. In this way the area of pasture is affected by changes of variables not included in the cattle-raising submodel making the behaviour of the cattle/pasture ratio rather unstable.

Since the results of the cattle raising submodel are sensitive to changes of this variable (see section 2.3 above), it was judged necessary to establish a maximum variation range for avoiding critical values of the cattle/pasture ratio. Thus, an upper limit for this variable was fixed that restored equilibrium in projections for all programme areas, except for Corumbá. This is a very particular area that comprises vast extensions of swampy lowlands (Pantanal) where land available for cattle raising varies permanently with changes in the level of the river.

For this reason and because of deficiencies in the transport infrastructure, this programme area has achieved a strong specialization in cattle breeding. Thus it normally sells a high proportion of young animals which are grown in areas with pastures of higher quality. In these circumstances the number of cattle transferred each year to other programme areas is relatively independent from variations in the cattle/pasture ratio, therefore a fixed value was assigned to this variable for the programme area of Corumbá.

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